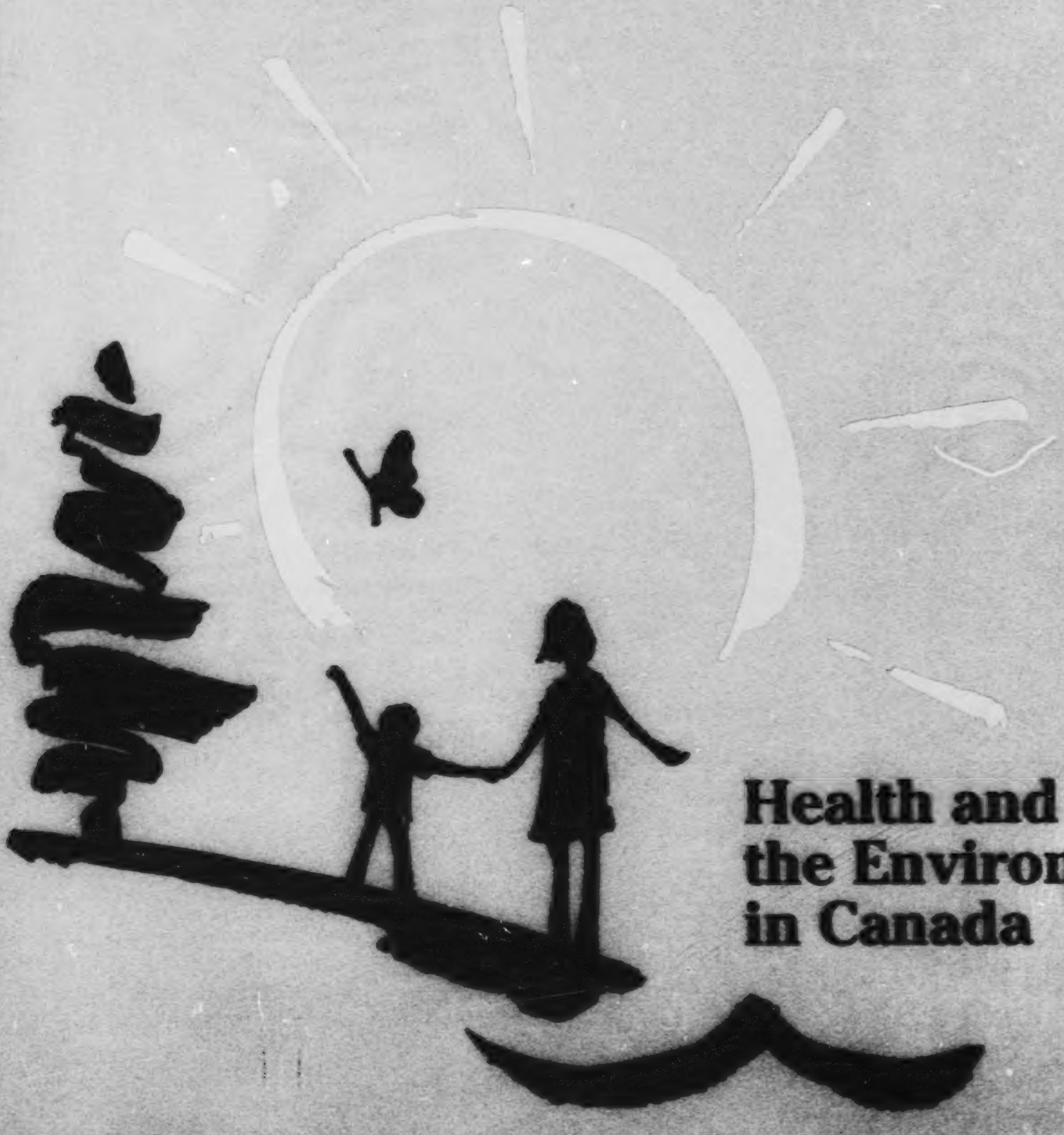
Health and Welfare Canada
Santé et Bien-être social Canada

A Vital Link



Health and the Environment in Canada

Canada

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Health and the Environment in Canada

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Preface

Canada has an enviable reputation among the world's nations for its diverse and beautiful environment, and for the general good health of its people. But Canadians must not take this fortunate condition for granted. We, like people everywhere, are affected by world conditions as well as national, regional and local ones. We must work to preserve and enhance our environment, because the link between health and the environment is vital to our current and future well-being.

With other partners in health, Health and Welfare Canada plays an important role in determining the health risks associated with natural and artificial environments, and in acting to improve the health and well-being of Canadians as they are affected by those environments. The Department uses a scientific approach to assess and manage risks to the general population, to Native Canadians and to other special groups. It also promotes health by encouraging physical fitness and by urging communities to become active in assessing decisions that may affect health.

Most of the information in this publication is based on studies conducted by federal government departments, particularly Health and Welfare Canada. Because of time constraints, the very important activities and findings of other levels of government, professional associations, public interest groups and private industry have not been included to any great extent. For a truly national picture of how the health of Canadians is being affected by the environment, this additional information must be taken into account.

This publication is intended to provide information to you about health and environment risks to assist you in making decisions about the issues that affect your health. While it would be desirable to measure all the risks of each of the hazards described, this is not possible with the current state of knowledge. In general, available information indicates that the risks to health from our environment are, at this point, relatively low for most Canadians. However, as described here, some of the risks are not yet well known, some groups are at higher risk than others, and some of the hazards warrant action by all of us.

It would be a major task to describe the benefits of our modern industrial society while at the same time discussing the possible hazards. Many of these hazards appear frightening if not viewed in relation to the total picture of life in Canada. We have only to look around us to realize that our lives are filled with a richness that includes substantial contributions from industrial activity. Modern medicines, abundant and high quality food, sturdy and comfortable shelter and efficient transportation are just a few of the things that make our standard of living very high. The discussion here is mainly designed to ensure that Canadians are aware of health hazards and of the need to limit or reduce these hazards.

One concept that must be emphasized over and over again is that, for any substance to be a significant risk, two things must happen: the substance must be a hazard – something that can do us harm – and we must be sufficiently exposed to the harmful substance for it to have an effect. It is often said that "the dose makes the poison." In other words, every substance known to humanity can be harmful or even lethal if enough is consumed. It is, therefore, important to remember that when the hazard of a given substance is discussed, we must also consider whether or not we are exposed to sufficient amounts of the substance for it to do any harm at all.

Measures currently exist to protect us from health hazards that have been recognized and documented. The challenge now is to continue to refine our knowledge of existing health hazards and to evaluate and assess new ones as they emerge.

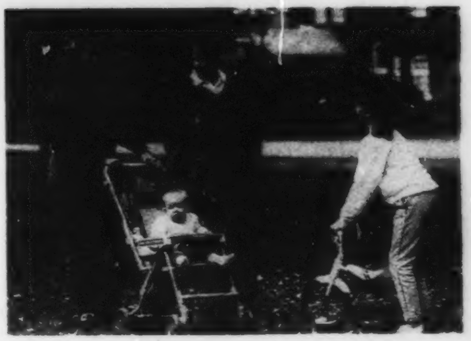
Chapter One
Our Health and Our Environment

Canadians are fortunate to live in a beautiful land of great natural resources and to be among the healthiest people in the world. So far, the environment has not generally put us at high levels of risk. Why then, have we been concerned for three decades about the environment and, more recently, about the effect of pollution?

Along with people everywhere, Canadians have come to realize that our world is fragile: indiscriminate use of its water, soil and air causes serious damage to the environment and the living things it nourishes.

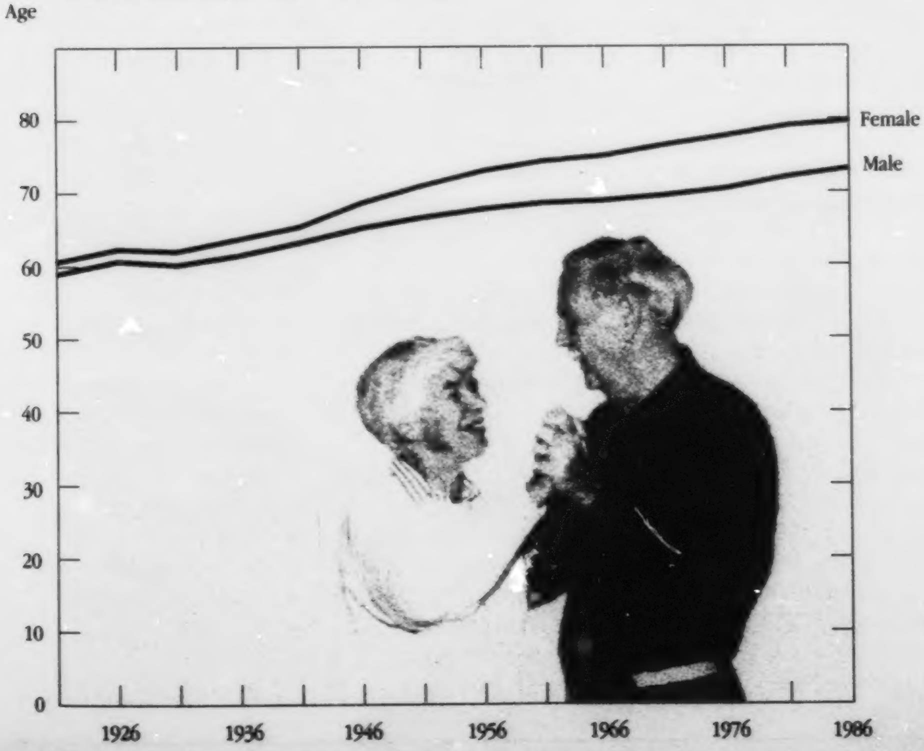
This century has brought startling changes. We have gone from the horse and buggy to the space satellite in the span of a single lifetime. However, along with some wonderful benefits, advances in technology have introduced new contaminants into the environment. Both these contaminants and the ones already found in nature affect people's health, so it is not surprising that Canadians are concerned about the effects of environmental pollution on health and safety.

It has long been known that nature affects our health. Natural disasters such as earthquakes, floods and drought have been a source of disease, injury, starvation and death throughout history.



Canadians are among the healthiest people in the world. We are, however, concerned about the effects of environmental pollution on health and safety.

Figure 1
Trends in Life Expectancy of Canadians[1]



Other natural agents can also be health hazards. These include bacteria and parasites in water, natural toxins in foods, and poisonous plants, insects and animals, as well as environmental radiation.

While naturally occurring health hazards continue to exist in Canada and around the world, both the growth in industry and the concentration of people in cities have contributed to new health problems. The technological advances of modern civilizations have dramatically improved the quality of people's shelter, clothing, food and water. These advances have contributed to the increase in the life expectancy of Canadians (see figure 1).

These advances, which have improved the quality of our lives in an equally dramatic way, have also resulted in a new set of potential health hazards. Chemicals and waste can contaminate water, and emissions from industry and transportation are changing the composition of the air. The mass production of food, which has so greatly benefited people everywhere, has introduced more chemicals into our diet and has to some extent affected the quality of our arable land. Overcrowding and poverty in cities leads to poor sanitation and living conditions.

Taken as a whole, conditions such as these create a complex web of interactions that can have serious consequences for our planet and its people. In recent years, these factors have deepened our understanding of health and the environment, and the vital link between the two. Now we are increasingly aware that human beings are part of the environment, which includes not only our natural surroundings but also our homes, workplaces and communities.

Canadians now are faced with important choices about how to preserve and enhance the environment. We need to know what

Public Opinions on Health and the Environment

During the last 30 years, Canadians have expressed a considerable interest in their environment. People rank it consistently as one of the top issues requiring action. While health issues arising from environmental pollution have been slower to elicit public interest and concern, they now rate highly in the minds of Canadians; indeed, taken together they are one of the principal reasons why Canadians are concerned about the environment.

In 1988, Environment Canada commissioned a study on the public's perceptions of environmental issues in Canada.[2] Public-opinion surveys, media monitoring and other research techniques were all used to find out how greatly Canadians were concerned about their environment. The study found that Canadians considered the environment to be first and foremost a human health issue, although concern for plant and animal life was also very high. A majority of Canadians believed that pollution was affecting their family's health. More than 90 percent of Canadians believed that there probably were many unknown hazards causing serious health damage; just under 90 percent felt that many people's health had already been affected by pollution. Canadians were particularly concerned about chemicals in water and air, and about protecting the water supply. This high level of concern has varied little over the past few years despite the nation's preoccupation with such topics as unemployment, the recession, and foreign or domestic unrest.

In a 1990 survey reported in the *Environmental Monitor*,[3] 97 percent of people surveyed indicated that they were somewhat or very concerned about the effect of environmental pollution on human health and safety. Additional polling of the Canadian public over the past few years revealed the following opinions on health and the environment:

- 82 percent of the respondents recognized that the natural environment is very important in helping people to be healthy;
- 73 percent believed that pollution is a major cause of cancer;
- 85 percent believed that pollution problems threaten the survival of the human race;
- 55 percent rated the Canadian food supply as reasonably safe, and a further 26 percent felt it was very safe.

The 1990 Health Promotion Survey found that 67 percent of Canadians felt that it was extremely important for the government to deal with environmental pollution, which was ranked first out of 14 issues affecting health.

The top environmental issues related to health that repeatedly arise in opinion surveys are:

- Air and water pollution
- Toxic chemicals
- Waste management
- Global warming
- Acid rain

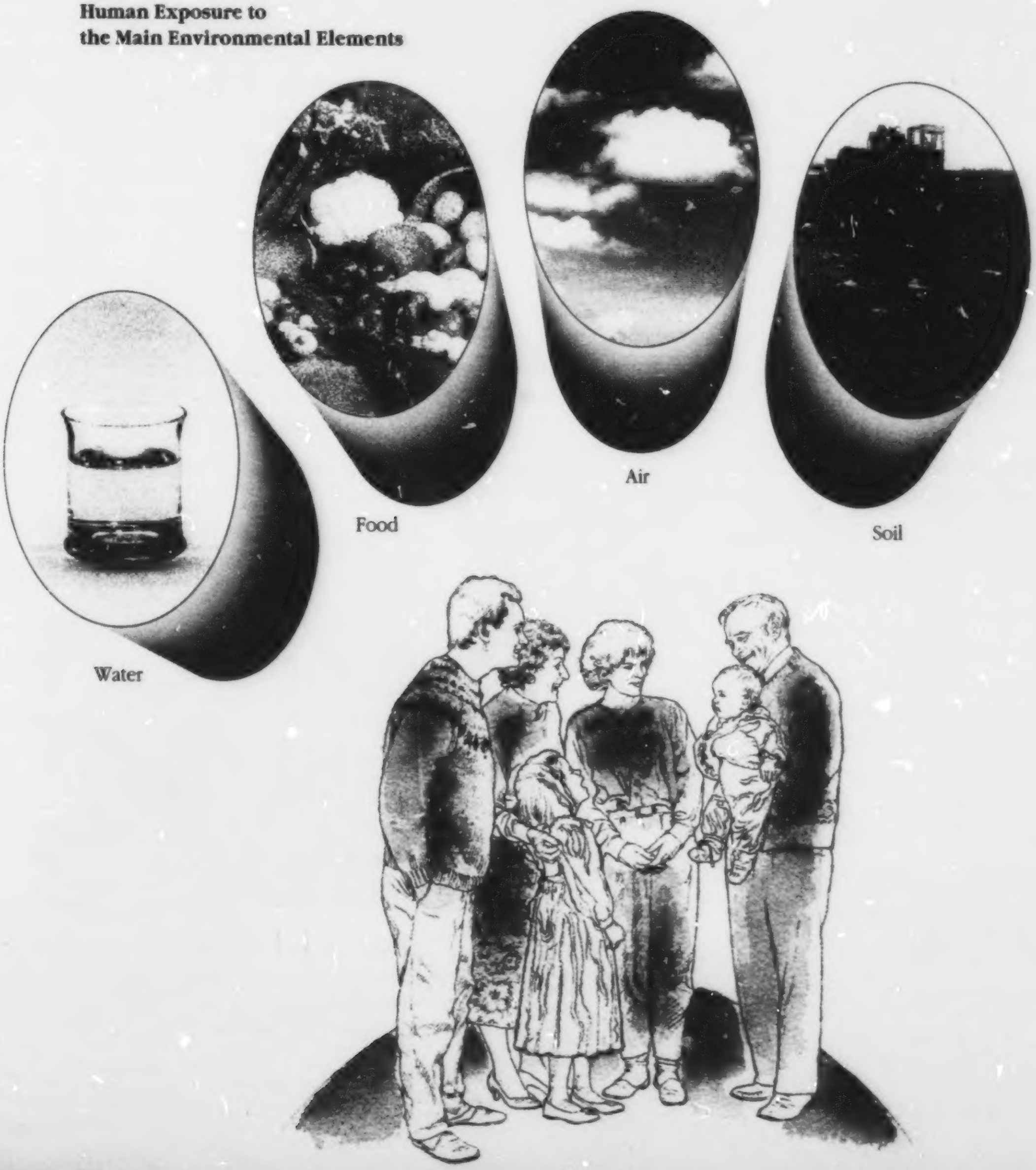
health risks we face and to work actively to find solutions.

Governments investigating and monitoring the health effects of environmental pollutants, communities improving their own health conditions, and individuals making lifestyle choices to better their health are all needed to make Canada and the world healthier and safer.

How Do Contaminants Reach Us?

Whether we sniff flowers, munch apples or go swimming, we are interacting in a complex way with our environment. We do many of these things automatically, without realizing that contaminants in the environment can enter the body the same way life-giving oxygen, food and water do: by breathing, eating and drinking, or through the skin's surface.

Figure 2
Human Exposure to
the Main Environmental Elements



Canadians enjoy a country with a reputation for open spaces and fresh, clean air. Every day we interact with our environment in many ways.

Exposure from the Air

Canadians enjoy a country with a reputation for open spaces and fresh, clean air, and breathing is one of the most direct interactions we have with the environment. It would be ideal to have air with no harmful contaminants. However, it is a fact of life that low concentrations of trace contaminants in the form of gas, vapour, airborne fibres, dust or other minute bits of matter can travel along with life-giving air to our lungs. Whether we relax at home or go for a walk, we may breathe in some pollutants. But we can act to prevent or lower our chances of this.

Indoor Air

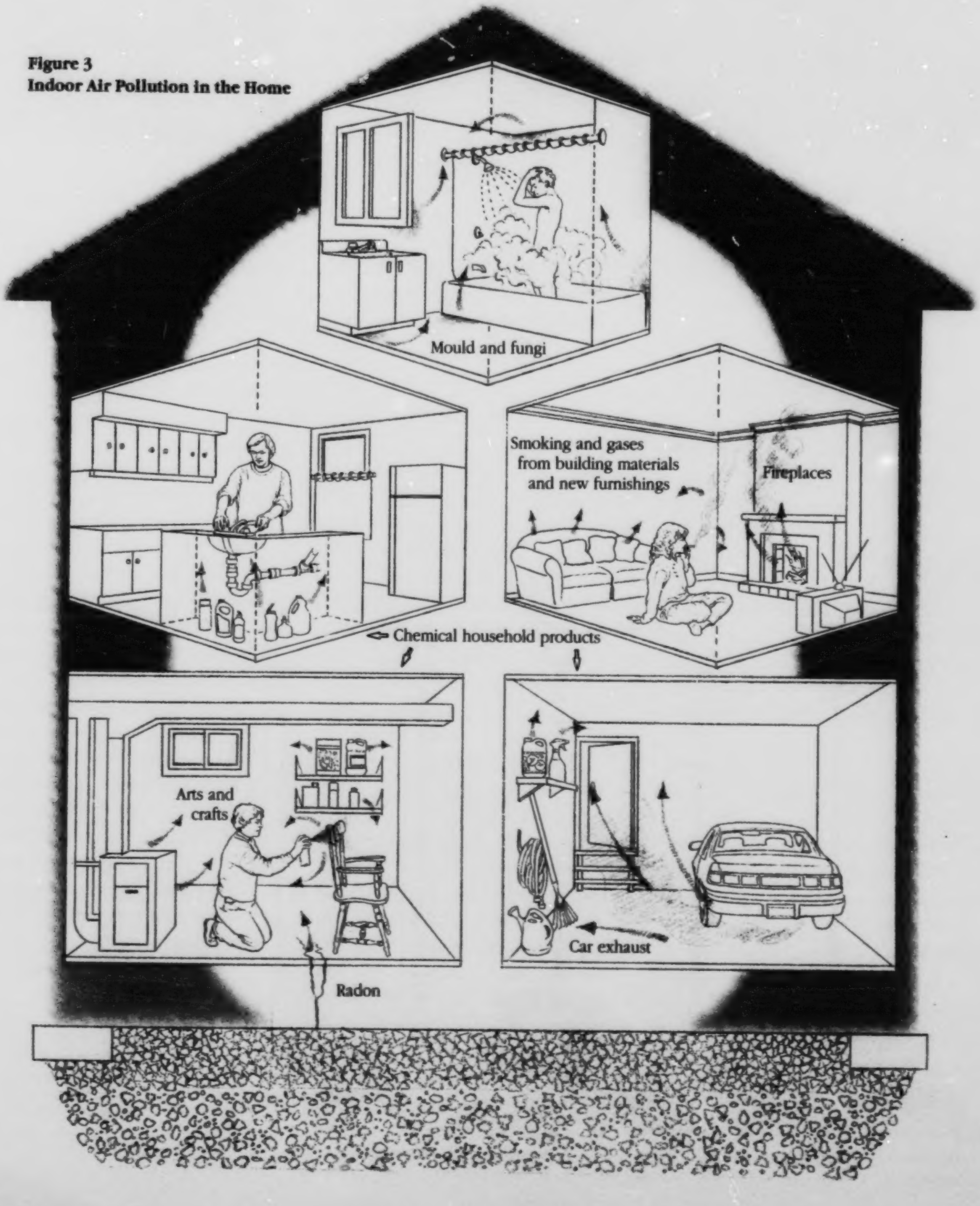
For the most part our homes, cottages and offices are relatively secure environments. However, conditions such as poor ventilation or sources of volatile chemicals can allow contaminants to concentrate enough to become uncomfortable or even potentially dangerous (figure 3).

In the fuel-conscious 1970s, some builders constructed airtight homes and buildings, cutting fuel and heating bills substantially but causing other problems. Because fresh air could not get in, contaminants accumulated indoors, causing people to complain about their health and comfort. This condition became generally known as "sick-building syndrome."

However, properly designed, constructed and operated buildings can be energy efficient and provide healthy environments for occupants. An example is the R-2000 program of Energy, Mines and Resources Canada (EMR), which developed an internationally recognized model of residential housing. Houses built to the standard all

Indoor air contaminants can come from a variety of sources, including tobacco smoke. Hundreds of contaminants are produced by smoking.

Figure 3
Indoor Air Pollution in the Home

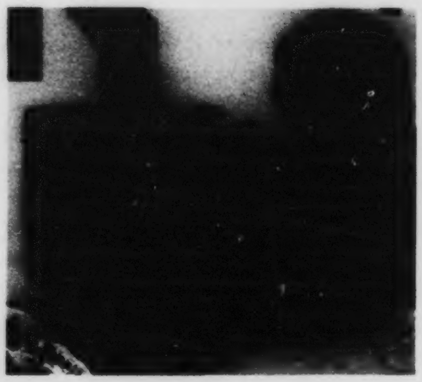

Mould and fungi
Smoking and gases from building materials and new furnishings
Fireplaces
Chemical household products
Arts and crafts
Car exhaust
Radon

contain mechanical ventilation with heat recovery.

Contaminants in indoor air come from a large number of sources, including gas stoves, kerosene heaters, furnaces, and power tools. As well, contaminants come from pesticides, paints, solvents, cleaners, tobacco smoke, gases released from building materials and furnishings, and from outdoor sources.

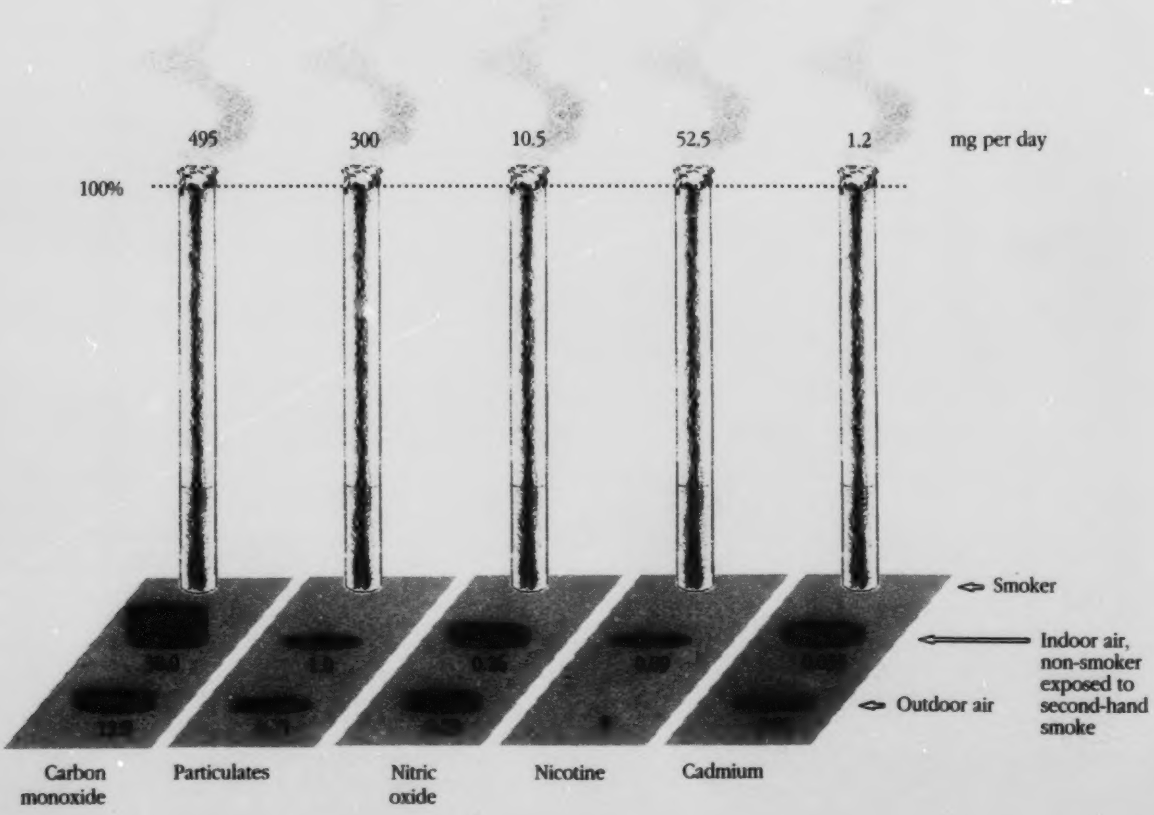
Figure 4 indicates the variation in exposure to several air pollutants:

1. from outdoor air in Hamilton, Ontario, where many industries are located;
2. from smoking 30 cigarettes per day; and
3. from exposure to second-hand smoke among non-smokers in the workplace.



Appliances such as wood-burning stoves and fireplaces, which help to make our homes comfortable, must be installed and used properly to prevent indoor air pollution.

Figure 4
Comparison of Exposure to Some Air Pollutants



It is apparent that both smoking and exposure to tobacco smoke result in much higher exposure to several contaminants than does exposure to air in an industrial city.[4]

The popular wood stove has caused problems in recent years. Wood stoves must be properly installed, vented, and maintained or they can become a major source of dangerous indoor pollutants. Kerosene heaters can also be dangerous if not used in properly ventilated rooms and with the correct grade of fuel.

People, as well as their pets and insects, can transmit viruses and bacteria. Fungi and bacteria can grow in humidifiers and on shower stalls; pollens, spores, cell debris and insects occur in household dust. An invisible gas called radon seeps from the ground into some buildings as well (see Chapter Six, "Radon").

The quality of our air is important to our health. Human-powered means of transportation are less polluting than the automobile.

Health and Welfare Canada, Canada Mortgage and Housing Corporation (CMHC) and Energy, Mines and Resources Canada are researching indoor air problems and identifying practical solutions. CMHC and EMR have studied some of the sources of indoor air pollution, especially gas spillage into the home from furnace combustion, and problems from soil gas – inflammable gas from some contaminated soils or former garbage dumps. CMHC publishes information to help people prevent or remedy air pollution at home, and has developed training courses for builders so that they can avoid problems in housing construction (see Appendix II).

Guidelines for Air Quality. Canada was one of the first countries in the world to recognize the importance of air quality in people's homes by developing officially recommended limits for pollutants.

Health and Welfare Canada, in collaboration with the provinces and territories, has established guidelines on air quality for certain potentially toxic substances or groups of substances in homes, ranging from carbon monoxide to tobacco smoke. The Department recommends acceptable concentrations for 10 substances, including formaldehyde and radon – colourless gases considered to have cancer-causing effects. Only qualified specialists on indoor air can accurately measure the level of these contaminants.[5]

The guidelines also suggest effective methods of reducing six other potentially harmful substances such as pest-control products and lead.

EMR, CMHC and National Research Council Canada, working through the Canadian Standards Association, have developed a ventilation standard called the "Residential Mechanical Ventilation Systems." It is intended to deal with contaminants normally encountered in homes and may be included in the 1995 National Building Code.

Outdoor Air

Outdoor (ambient) air surrounds the earth and makes up the atmosphere. Unfortunately, the atmosphere is sensitive to air pollution from activities such as chemical use, burning fuels, automobile exhausts, manufacturing, and smelting ores.

The Effect of Transported Air Pollutants on Respiratory Function

The phenomenon of acid rain has brought a lot of attention to the movement or transport of pollutants over large distances. Researchers at Health and Welfare Canada, along with colleagues from the Harvard School of Public Health, have performed studies to assess the relationship between air pollution in remote regions and respiratory function in children.

At one camp at Lake Couchiching, Ontario, in 1983, and at another Girl Guide camp at Lake Erie in 1986, the researchers monitored air pollutant levels and tested the lung function of the young campers daily. Although the areas are remote from urban and industrial centres, weather patterns can move air pollutants to them. When levels of certain pollutants were high, the researchers found a slight decrease in the measurements of campers' lung functions. Some campers registered a delayed response to higher levels of sulphates and fine particulate matter in the air, meaning that their lung function decreased 12 and 24 hours after the exposure. Exposure to increased levels of an irritant pollutant such as ozone caused the campers' lung function to decrease immediately.[6]

The reductions in lung function recorded in these studies were small but statistically significant. While these effects appear reversible, long-term effects of repeated irritation to the respiratory system are not well understood. It is possible that repeated attacks predispose children to the development of chronic lung disease in later years.[6]

Airborne acidic material ("acid rain") is known to harm the environment. Recent studies have shown that acid rain can also affect human health.

Our health is directly affected by air pollutants originating from a number of sources. These air pollutants, sometimes referred to as "greenhouse gases," include carbon dioxide, methane, nitrous oxide and chlorofluorocarbons (CFCs). They can affect us at the global, regional and local levels.

The contamination of the entire planet's atmosphere and the diffusion of pollutants throughout the world are often referred to as global effects. Direct health effects from inhaling pollutants are not usually considered global, although indirect health effects from pollution on this scale may be very significant.

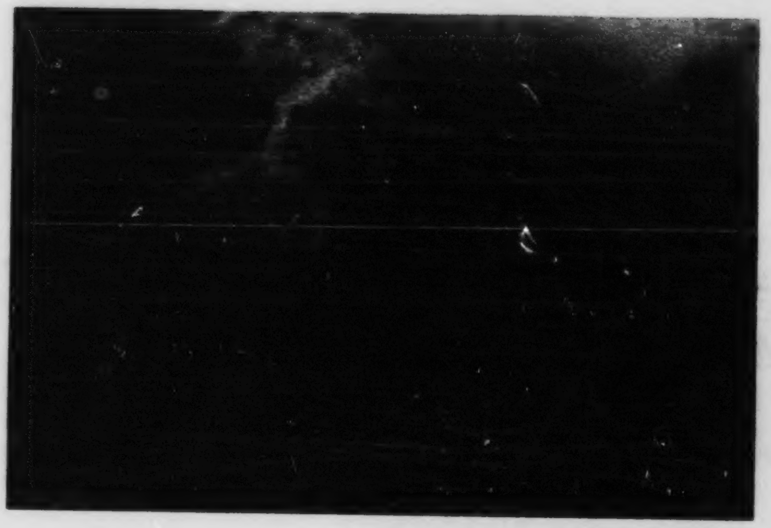
Global air pollution results in health effects that are far more subtle than those from local and regional sources. These effects result from environmental changes caused by the global presence of pollutants, rather than the pollutants themselves. For example, increased skin cancer and cataracts could result from the reduction of ozone in the stratosphere. (Ozone is a gas that, in the upper atmosphere, protects us against the sun's ultraviolet light. However, at ground level, ozone is a component of smog and can affect the lungs.)

At the regional level, pollutants moved from distant sources by wind and weather can cause health problems and contaminate the environment in places where not much pollution is produced locally. This can happen when contaminants released into the environment by energy production and use, industry, agriculture or various urban activities are transported long distances by the movement of air masses. Even pollutants transported far from their source may affect people physically. Airborne acidic material, often referred to as acid rain, is a type of regional air pollution, since it may be carried a long way. Acid rain is discussed in Chapter Three, under "Air Pollutants."

At the local level, people can breathe in air pollutants from nearby pollution sources. Day-to-day living with contaminated outdoor air may have cumulative health effects. In some cases, a definite link between a certain pollutant and a specific ailment can be shown, such as the presence of excessive airborne lead in the environment which, if exposure persists, can cause subtle brain damage in young children.[7]

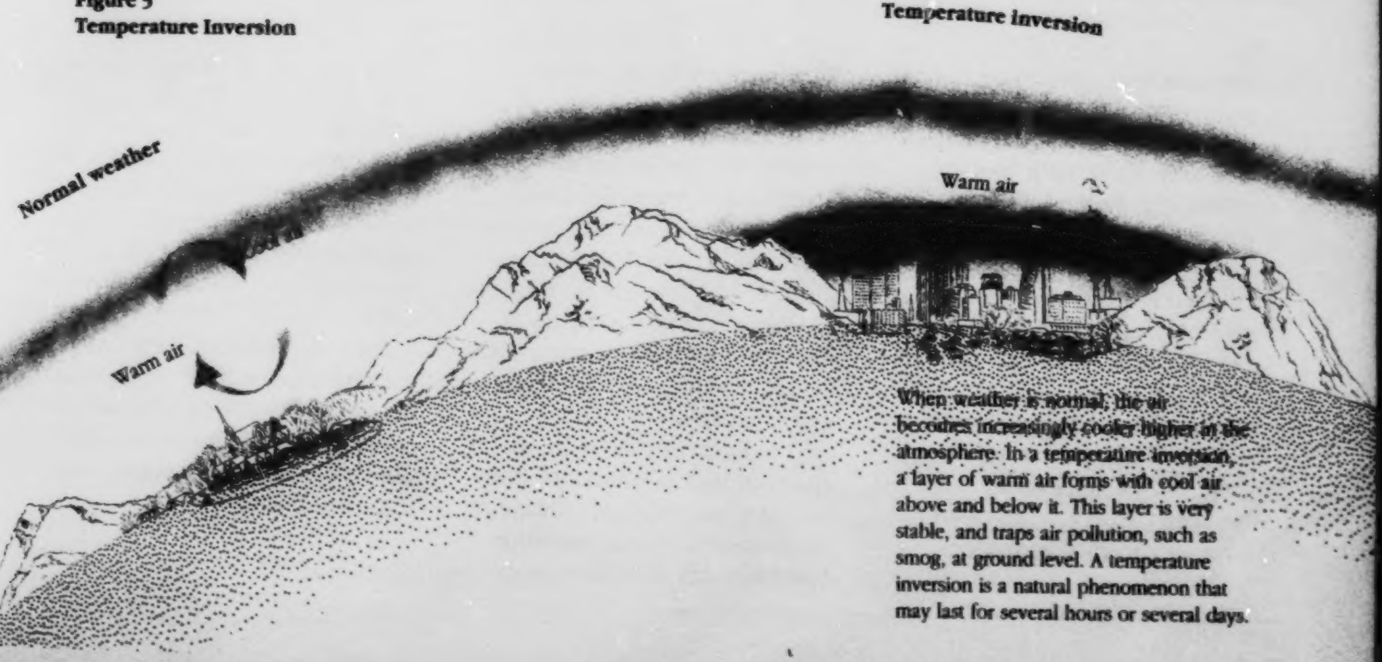
Local pollution can be very severe. For example, air pollution was so heavy in the industrialized Meuse River Valley in Belgium as well as in Donora, Pennsylvania, and in London, England, that it caused deaths.

London is the most extreme and recent example. The city was famous for "pea-soup" fog, named for the colour of air pollutants from the soft coal people burned in open fireplaces. In December 1952, a five-day temperature inversion (see figure 5), a natural occurrence, trapped pollutants near the ground



Contaminants may be released into the environment and be transported long distances by the movement of air masses. Even pollutants transported far from their source may affect people.

Figure 5
Temperature Inversion



When weather is normal, the air becomes increasingly cooler higher in the atmosphere. In a temperature inversion, a layer of warm air forms with cool air above and below it. This layer is very stable, and traps air pollution, such as smog, at ground level. A temperature inversion is a natural phenomenon that may last for several hours or several days.

The Relationship Between Air Pollutant Levels and Hospital Admissions: A Southern Ontario Study

Short episodes of severe air pollution have had dramatic consequences in terms of human illness and death. However, the effects of lesser, "normal" variations in pollution levels remain largely unknown. Some studies have tried to show relationships between levels of various common pollutants and human illness as shown by numbers of hospital admissions for respiratory ailments.

One such study, done by researchers from the University of British Columbia, covered the geographical area between Windsor and Peterborough in Southern Ontario. This area takes in the Toronto-Hamilton industrial corridor, as well as Sarnia and Windsor, two smaller cities that are also heavily industrialized. Also, Detroit is right across the river from Windsor. Agriculture dominates the rest of the region, which is dotted with towns, smaller cities and rural communities. The population of the region during the 1974–78 survey was approximately 5.7 million people.

For January and February, and July and August for each of the years of the study except 1975, hospital admission data were gathered from 79 acute-care hospitals in the region. These data included information about the reasons for admission – that is, whether the individuals were admitted for respiratory ailments or not. These hospital data were then compared to data on levels of pollutants. These data came from 15 air sampling stations operated in the region by the Ontario Ministry of the Environment. Levels of sulphur dioxide, ozone, nitrogen oxides and particulate matter – fine particles in the air – were tracked, and air temperature was also recorded.[8]

For the months of July and August, the researchers found that hospital admissions for respiratory illness were indeed significantly linked to sulphur dioxide levels, ozone levels, and temperature. For the months of January and February, temperature was the only variable that had a significant effect on hospital admissions for respiratory illness. The non-respiratory illnesses tracked in the survey showed no association with levels of air pollutants or temperature.[8]

Later studies by the same research team found a stronger association with sulphate than sulphur dioxide when they charted the link between elevated levels of pollutants and hospital admissions for acute respiratory conditions. The studies also concluded that the real cause of these respiratory problems may, in fact, be some as-yet-unmeasured pollutant, such as sulphuric acid aerosol. The researchers also thought that some particular pattern of exposure might be necessary to produce a significant respiratory health effect. This means that the exposure to pollutants may occur in some order or be cumulative before causing respiratory problems.[8]

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and kept the pollution from dissipating. An estimated 4 000 people died and about 6 000 others were sent to hospital. Such "pollution events" are particularly hard on the elderly, or people with various heart or lung ailments. This episode resulted in legislation controlling coal burning, and there has not been another "killer fog" since that day.

Canada has not experienced pollution anywhere near this magnitude, but studies have shown a link between concentrations of air pollutants and hospital admissions.

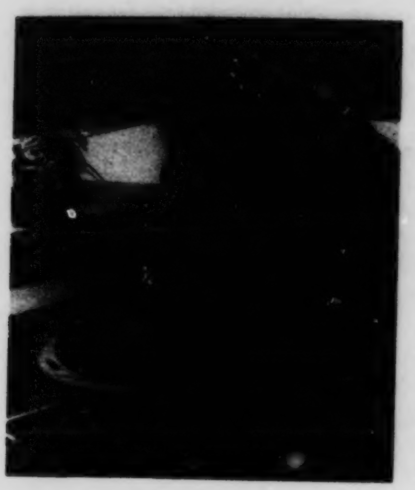
Exposure by Eating and Drinking

While food and drink sustain us, they are usually the major way contaminants enter our bodies. Disease-causing micro-organisms have always existed, and since the beginning of time people have had to worry about safe supplies of food and water. We must handle food and water properly, or risk becoming sick.

The World Health Organization estimates that 30 000 people die each day as a result of contaminated water and poor sanitation. Approximately 25 million people, or the equivalent of Canada's population, die from preventable waterborne diseases each year.[9]

While most serious illnesses due to contaminated food or water occur in the less industrially developed parts of the world, we are by no means free of these problems in Canada.

Since the Industrial Revolution, we have created many new potential hazards and some of these may contaminate food and water supplies when they are released into the environment.



Canada's food supply is among the safest in the world. However, it is still important for us to learn to take simple measures, such as washing vegetables and fruit, to minimize our exposure to pollutants.

While it is somewhat artificial to divide things into what we eat and what we drink, certain contaminants reach us more often in one way than another.

Food

While Canada's food supply is among the safest in the world, it is important for us to learn about potential problems in order to prevent them. There are many opportunities for various contaminants to enter the complex chain of events that brings food to our tables. The basic elements of soil, water and air are all subject to pollution, so each stage in the production of food – growing and harvesting crops, raising and slaughtering animals, storage, preparation, packaging and handling – has its own potential risks for contamination.

The concentration of these chemicals in rivers, lakes and oceans may be quite low. They become more concentrated, however, when taken in by microscopic plant and animal life, and even more concentrated in the tissues and organs of small fish that eat the plants. Larger fish eat the small ones, and the concentration of chemicals becomes still higher, and so on up the food chain. At each step in the chain, the concentration of the potentially harmful substance increases because the organism stores the substance in tissue (usually fat tissue in higher organisms) before it can be broken down and expelled from the body. This process is called bioaccumulation. Concentrations could reach toxic levels

Careful agricultural practices result in safe and nutritious products.

Dioxins and Furans in Milk Cartons

In 1988, as part of its ongoing monitoring of the safety of the Canadian food supply, Health and Welfare Canada detected minute amounts of dioxins and furans in cows' milk that was packaged in cardboard cartons. These chemicals are normally associated with the wood pulp bleaching process.

As a result of these findings, the Department and members of the dairy and the pulp and paper industries undertook a joint program to study the levels of dioxins and furans in the cardboard used in milk containers, and the migration of these substances into the milk.

The investigation used a method by which extremely low levels of dioxins and furans can be detected – to a level of one part per trillion (ppt). This resulted in the development of mechanisms to reduce the formation of these substances in the manufacture of cardboard for milk containers. Manufacturers are now using a modified bleaching process for the cardboard. This process has resulted in no detectable levels of dioxins and furans in milk, even after extended periods of storage.

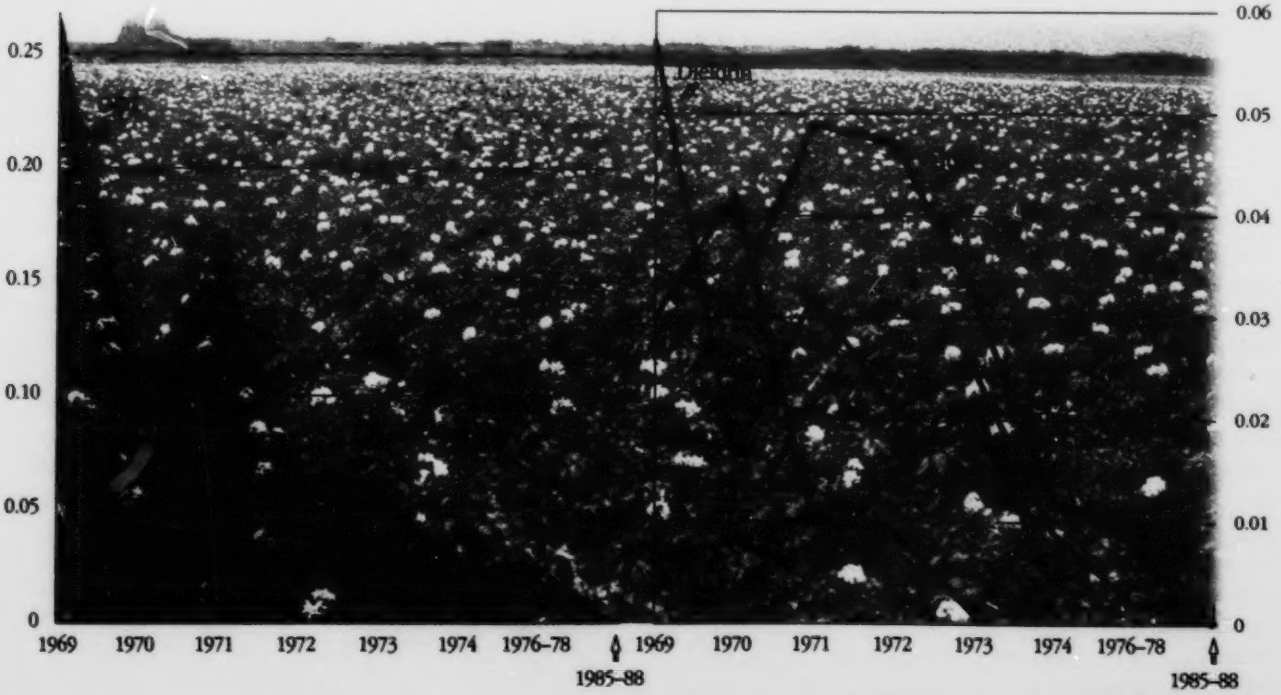
The Total Diet Survey

Over the years Health and Welfare Canada has conducted surveys to estimate the levels of chemicals to which Canadians are exposed through their food. For this purpose, samples of foods commonly eaten by Canadians are prepared in the laboratory just as they would be at home: raw meats are cooked, vegetables are cleaned, trimmed and cooked, and processed foods are prepared according to the directions on the label. The foods are then tested for chemical contaminants such as lead, dioxins and pesticides. Using information about the eating habits of Canadians – for example, what foods we eat, and how much we eat daily – scientists then estimate the levels of contaminants we consume in our total diet.[10]

The first total diet survey was done between 1969 and 1973. A second survey ran from 1976 to 1978, and a third from 1985 to 1988. Since it began, the survey has changed a great deal, responding to changes in knowledge and technology. For example, the list of foods Canadians commonly eat has become more accurate as more surveys are done. Newer analytic methods and technology also make it possible to detect a wider range and smaller quantities of contaminants.[10]

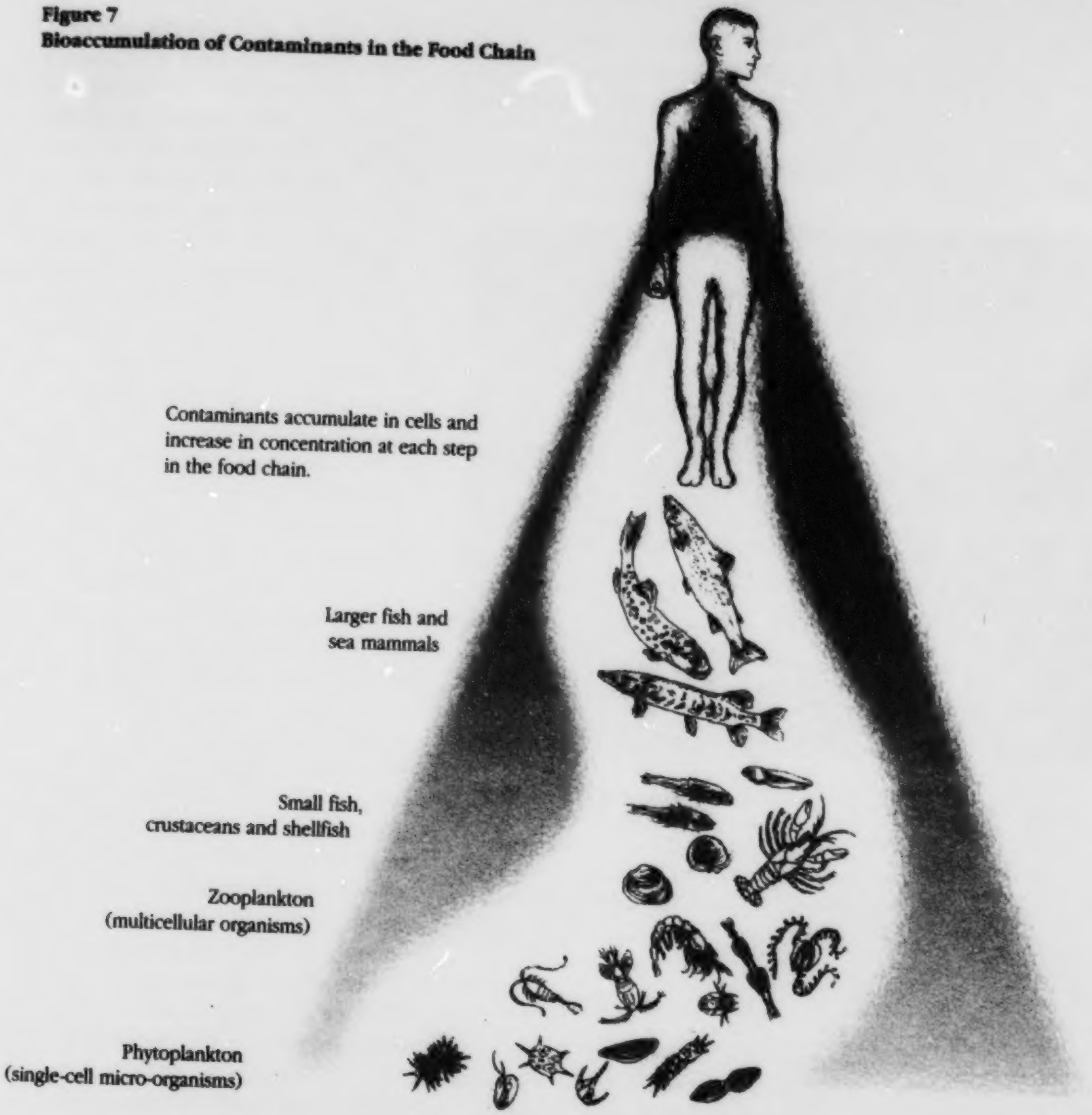
Over the years, these surveys have shown that the levels of contaminants to which Canadians are exposed in their food are far below levels set in national and international guidelines. Indeed, the levels of some contaminants, including the pesticides DDT, HCH, and dieldrin, have decreased significantly over the past 20 years (see figure 6).

Figure 6
The Dietary Intake by Canadians of DDT and Some Other Pesticides[10, 11]
(in micrograms per kilogram of body weight per day)



World Health Organization acceptable daily intake (μg/kg body weight per day) for DDT is 20; HCH, 8; dieldrin, O.1; endosulfan, 6; and malathion, 20.

Figure 7
Bioaccumulation of Contaminants in the Food Chain


Contaminants accumulate in cells and increase in concentration at each step in the food chain.
Larger fish and sea mammals
Small fish, crustaceans and shellfish
Zooplankton (multicellular organisms)
Phytoplankton (single-cell micro-organisms)

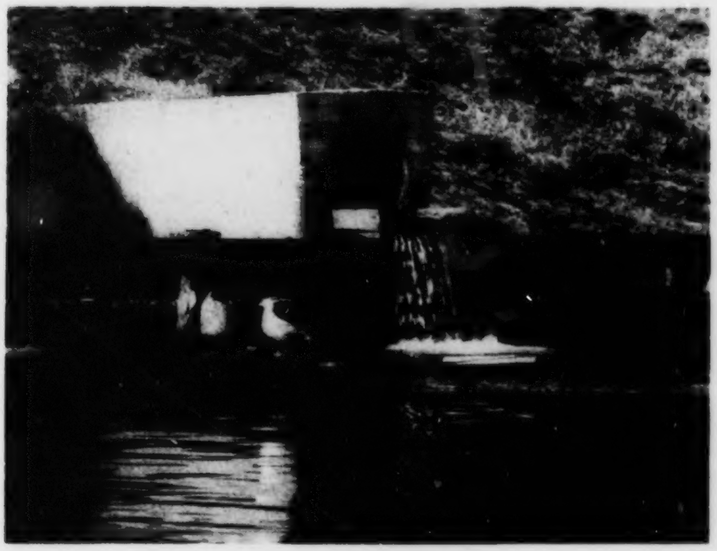
by the time the chemicals reach animals and people at the top of the food chain (see figure 7).

The pesticide DDT, which can bioaccumulate, has in the past had a severe impact on aquatic birds' reproduction in certain areas. Testing some populations of these birds for DDT and PCB contamination has shown a substantial decrease in concentrations from the early 1970s.[12]

PCBs are a group of extremely long-lived chemical compounds used as an insulating fluid in electrical transformers. The use of PCBs in transformers is being phased out, however, and PCBs are banned for any new products.

Mercury is a toxic metal that can affect human health. Although the human body has some ability to cleanse itself of this heavy metal, the intake of high concentrations in foods such as fish and seafood over a period of time can seriously affect the nervous system, particularly in children and especially in the fetus.

The risk to health increases significantly for people such as some Native Canadians who regularly eat large amounts of fish or other animals exposed to high concentrations of contaminants such as PCBs and mercury. In the case of fish, federal, provincial and territorial governments set standards to guide



While Canada has abundant fresh water for drinking purposes, this resource must not be taken for granted, since it is evident that pollution from modern society can affect our drinking water sources.

people in determining where contaminated fish are located, the species of fish that are contaminated, and the amount and parts of fish that can be consumed without risk to health.

Micro-organisms could be a serious problem in Canada if it were not for regulations and programs undertaken by all levels of government to ensure public safety. The situation is much worse in less developed parts of the world, where disease carried by food and water can be catastrophic. The rate of occurrence of some foodborne illness has increased in Canada in the last few years. This is in part due to an increase in the number of disease-causing agents (pathogens) in foods. This increase may also be due to poor practices in food handling, or increased reporting or recognition of this kind of illness.[13]

The use of substances such as growth hormones or antibiotics in animals raised for food has been controversial, since these substances are thought to be "bioactive," that is, residual amounts of these compounds remaining in food might continue to be active and affect the consumer. Scientifically, the chance that this could occur is very slight since the body's digestive processes would destroy most residues before they become a problem. Furthermore, cooking would render most growth hormones inactive.

Health and Welfare Canada has taken steps to ensure that the use of substances such as antibiotics in animals poses no risk to the health of consumers. Manufacturers must include on product labels the amount of time that must pass between the administration of drugs and the slaughter or milking of food animals, so that either the chemicals leave the animals' systems or the level of chemical residues is safe.

Pesticide residues, where they occur in treated crops, are generally reduced through natural means (biodegradation) or normal processing, such as washing, by the time the food reaches the consumer. However, residues of some pesticides are more persistent. In either case, scientists develop limits or acceptable levels for pesticides in food; in some cases the pesticide may simply be banned. Scientists are actively seeking to develop alternatives to pesticides.

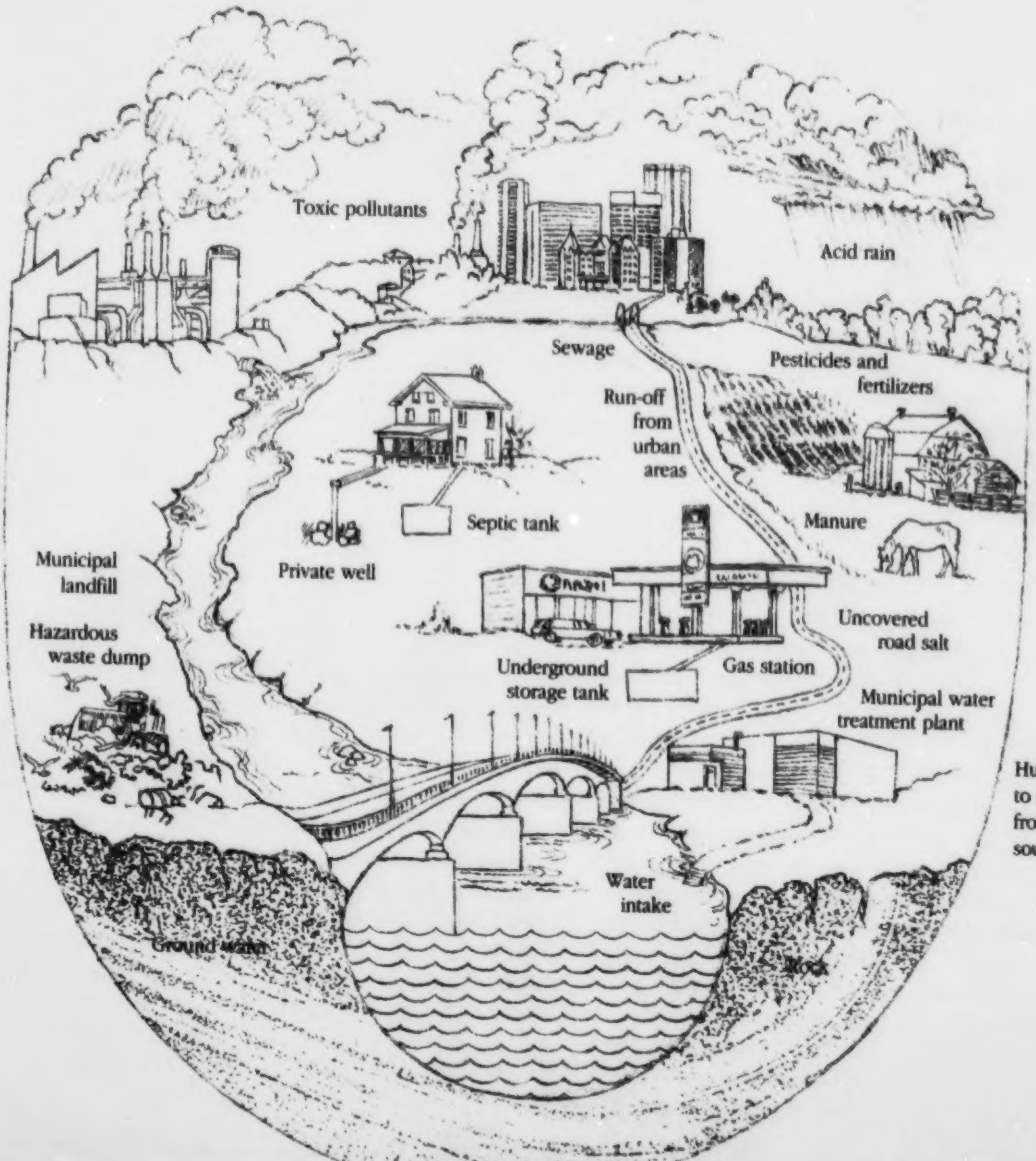
Drinking Water

Canada is in the enviable position of having great riches of fresh water within its boundaries. We also have some of the best drinking water in the world.

Although 75 percent of our planet is covered by water, only a limited and stable percentage (2.5 percent) of this water is fresh.[14] Canada has approximately 15 percent of that available water. We must not take this wonderful resource for granted, since it is becoming evident that water pollution reaches all parts of Canada.

Water is composed of two atoms of hydrogen and one atom of oxygen, and is an extremely good solvent – that is, it dissolves a certain amount of almost anything. Many

Figure 8
How Water Can Become Contaminated[15]


Toxic pollutants
Acid rain
Sewage
Pesticides and fertilizers
Run-off from urban areas
Septic tank
Private well
Manure
Municipal landfill
Hazardous waste dump
Uncovered road salt
Underground storage tank
Gas station
Municipal water treatment plant
Water intake
Ground water
Rock

Humans are exposed to contaminated water from a number of sources.

chemicals dissolved in water are not harmful, and may indeed be essential for people. For example, calcium is dissolved from calcium carbonate in rock formations below the surface. It is valuable in forming human bones and teeth. As well, it is involved in important processes in each cell in the body.

Unfortunately, both human activities and natural chemicals and organisms can contaminate valuable drinking water which then requires expensive treatment to remove the contaminants (see figure 8). For instance, agricultural chemicals can pass into rivers and streams (surface water), or underground storage tanks can leak and contaminate water that seeps through the ground into springs and wells (ground water). In many areas of Canada, domestic sewage and

Just a Bit Can Contaminate a Lot of Water

Water quality can be a very fragile thing, and sometimes a very small amount of a contaminant can greatly affect a large volume of water. Here are some examples.[14]

- One drop of oil can make up to 25 litres of water undrinkable.
- One drop of a common herbicide 2,4-D can contaminate 10 million litres of drinking water.
- One gram of lead in 100 000 litres of water makes it unfit for drinking.
- One gram of PCBs can make up to one billion litres of water uninhabitable for freshwater aquatic life.

Guidelines for Canadian Drinking Water Quality

Since 1968, Health and Welfare Canada and the provincial health or environment ministries have been publishing the *Guidelines for Canadian Drinking Water Quality.* The guidelines suggest maximum levels for certain substances that may be harmful to health. The guidelines are not enforced by federal law because drinking water is largely a responsibility of the provinces, territories and municipalities. However, in almost all the provinces, these guidelines do form the basis for drinking water objectives.

The guidelines recommend levels for both microorganisms, such as bacteria, and for chemicals. Contaminants in drinking water may come from a variety of sources. They may include naturally occurring substances such as arsenic, natural and industrial radioactive chemicals such as radon, and synthetic chemicals from industrial processes and agriculture, such as pesticides. Some contaminants may be formed during the process of treating water, and substances such as lead and copper may come from the materials used in the water distribution system itself.[16]

The levels of chemicals in the guidelines are expressed as Maximum Acceptable Concentrations (MACs). These levels, usually measured in parts per million (ppm), indicate the highest concentration of a substance in drinking water that is considered safe for human use. The methods used to determine the MACs ensure that they are far below exposure levels at which any adverse health effects have been observed – that is, 10 to 10 000 times. Exposure to water containing a contaminant at the MAC level is expected to have no impact on health. Water which consistently contains levels of a substance above the Maximum Acceptable Concentration may be harmful to health.[16]

In 1989, the fourth edition of the *Guidelines for Canadian Drinking Water Quality* was published. This most recent edition includes several new guidelines, as well as revisions to 11 of the guidelines contained in the 1978 (second) edition. The provincial, territorial and federal governments will continue to revise the guidelines to ensure that they are based on the most recent scientific data.

storm water run-off are still the major sources of pollution. Natural contamination can come from mineral deposits containing lead and cadmium.

As we have increasingly come to recognize these potential problems, governments have done more and more in the way of sponsoring research, making regulations and exerting control over the quality of our waters. Sensitive tests have been developed over the years to measure quantities of both natural and manufactured chemicals in water; these are routinely used by provinces, territories and municipalities, which have the primary responsibility for providing safe drinking water in Canada.

Guidelines. While the procedures for testing drinking water were once somewhat crude, we now can identify concentrations of some chemicals in water as low as one part per trillion (ppt) or even parts per quadrillion (ppq). In fact, our sophisticated equipment for measuring smaller and smaller quantities of chemicals ensures that new contaminants will continually be identified in water. The contaminants may or may not be new, but our ability to detect them is new. The measures for judging whether water is safe or unsafe for consumption are the *Guidelines for Canadian Drinking Water Quality* published by Health and Welfare Canada. These guidelines recommend maximum acceptable levels of many chemicals, micro-organisms, and radioactive substances. Provincial governments apply these guidelines, according to their own legislation and procedures.

Water Treatment. In most cities, towns and villages, water destined for home consumption is treated to kill harmful micro-organisms. This treatment has been one of the most significant public health advances ever made. It is unfortunate that many millions of people around the world still do not have access to it. The treatment is done by adding chlorine or sometimes ozone to the water and, in many cases, by filtration to remove sediment and some organic matter. However, water treatment systems often do not remove trace contaminants – natural or human-introduced chemicals present at extremely low concentrations – because most systems were not designed to do so.

Treatment procedures themselves may introduce water quality problems. Chlorine used to kill bacteria in drinking water can also react with decaying natural animal and vegetable matter to produce trihalomethanes, chemical compounds potentially harmful to human health because of their link to cancer in tests on laboratory animals. Canada's drinking water guidelines suggest maximum acceptable limits for certain substances, including trihalomethanes.

However, to be at any real risk, a person would have to receive a significant dose over a lifetime. The benefits of chlorinating water far outweigh the potential threat to health, since diseases caused by waterborne micro-organisms are still the greatest hazard in our drinking water.

Tap Water. The overall quality of municipal water supplies in Canada is extremely good. The fact that water is of high quality when it leaves the municipal water treatment plant is, however not an absolute guarantee that it will be of the same quality by the time it is consumed. There may be problems with the distribution system of underground pipes used to deliver water to homes, with holding tanks, and with pipes and fittings in the home, apartment building or place of business.

Lead can enter the water supply from lead pipes, brass fittings and lead solder, as well as from some types of metallic-hardened plastic pipe. Also, cadmium can pass out of pipes made of lead, plastic or copper, and leach as well from galvanized piping and tanks and contaminate the water. These difficulties may be increased if the water is soft.[17]

For this reason federal, provincial, and municipal government agencies conduct tests on water in the distribution system, and for metals leaching from plumbing parts. These agencies also participate in developing standards for materials used in contact with water. Thus, the overall threat of lead in drinking water in Canada is considered very low.

Alternatives to Tap Water. Although the overall quality of municipal water in Canada is good, many Canadians feel unsure of the quality of their drinking water. A good number have turned to using bottled water for drinking and cooking,

The Toronto Drinking Water Study

Public concern about the quality of municipal drinking water has prompted many people to use devices to treat their water in the home or to choose bottled water as an alternative. Whether or not these alternatives are an improvement over tap water has become an issue. Bottled water is subject to regulations and standards but there is no evidence that it is safer than tap water. The quality of water after treatment by a point-of-use device is unregulated. Thus, the quality of water from these alternatives may, in fact, differ little from that of tap water from a municipal system.

In Toronto, surveys indicate that between 22 and 30 percent of residents use alternatives to tap water. Largely because of the obvious public perception that tap water is unsafe, the Department of Public Health in that city conducted a study to compare the quality of drinking water from various sources. It led to the publication in September, 1990 of *Summary Report: The Quality of Drinking Water in Toronto: A Review of Tap Water, Bottled Water and Water Treated by a Point-of-Use Device.*

Tap water came out ahead. Although trace chemical contaminants were found in all three types of water, contamination by bacteria was noted frequently in device-treated water and bottled water, and was not found in tap water. While some of the chemical contaminants in tap water may be a risk to health – for instance, lead levels are sometimes high in water that has been standing in the pipes unless the tap is run for a while – the Toronto Department of Public Health came down solidly in favour of municipal water. In the summary of the study, the department states:

> *In the view of the Department of Public Health, tap water is currently the best choice for drinking water in terms of health considerations. The Department does not promote the use of alternatives because of their currently inferior bacteriological quality, their variable chemical quality, and the lack of applicable standards to guarantee the quality of product to the consumer.*[18]

At the time the Toronto drinking water study was undertaken, bottled water was not required to meet the same quality guidelines as tap water. Health and Welfare Canada is changing regulations to include this requirement.

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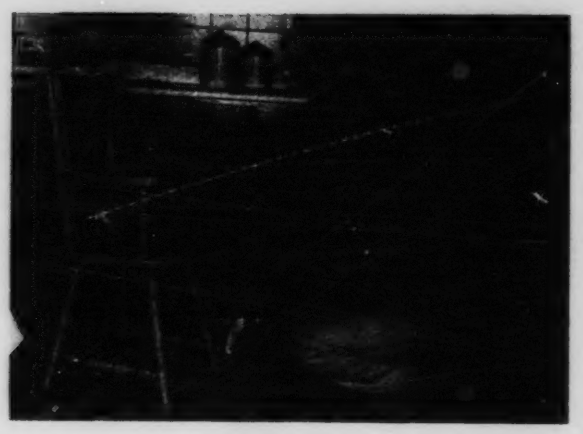
feeling this offers them a safer alternative. As well, approximately 10 percent of Canadians use water treatment devices on their taps. Neither alternative is free of problems, or necessarily is better than municipal drinking water.

At the time of the Toronto drinking water study, bottled water was not required to meet the same quality guidelines as tap water. Health and Welfare Canada is changing regulations to include this requirement.

As part of its compliance program, Health and Welfare Canada conducted surveys from 1983 to 1989 on the microbiological quality of spring and mineral water sold in bulk, and water sold in sealed containers.[19] The results were similar for both groups of water: two to three percent of samples tested exceeded the coliform bacteria standard and 34 percent exceeded the colony count standard (total bacteria). In addition, a survey of chemical contaminants in bottled water was conducted from 1986 to 1989. All samples conformed to the *Guidelines for Canadian Drinking Water Quality.*

The marketplace has a great variety of water treatment devices for the home and, as usual, the consumer should be cautious. While these devices may be effective in removing chemicals and in improving taste and odour, some may lead to the build-up of micro-organisms and chemicals.[20]

The most serious problems occur with devices that use activated carbon filters. Studies have shown that the bacteria in the water will accumulate and multiply in the filter. This means that, with time, the filtered water contains more bacteria than does non-filtered water. Studies have shown that these concentrations of bacteria may be 2 000 times higher than in unfiltered



Safety precautions printed on product labels should be followed closely. Spray painting should be done outdoors or in a well-ventilated area.

water.[20] Even so-called "bacteriostatic" water filters containing activated carbon with silver are subject to this bacterial growth. Filters must, therefore, be replaced regularly and water treatment devices should be flushed for about 30 seconds before the water is used for drinking.

Most homes do not need a water treatment device unless there is a contaminated private water supply, such as a private well. As well, Health and Welfare Canada strongly recommends that water treatment devices that do not disinfect water should only be used to treat water already treated by the municipality, or on wells that are regularly tested and meet the microbial guidelines. Thus any bacteria that do grow will not likely be harmful types.

Exposure through the Skin

Although the skin is a tough protective barrier to the body, it is permeable – that is, it may be penetrated throughout. Whenever our bodies are exposed to air, soil, dust and water, there is the possibility of exposure to contaminants. Usually skin exposure is the least important route.

When people are exposed to certain compounds in this way, they may develop skin diseases. As well, the exposure may contribute to a "total load" on the body system, meaning that the amount absorbed by means of skin contact is added to the amount taken in by breathing and ingestion. This total load must be considered in order to estimate the risk of disease.

Workers in certain jobs often have a high level of skin (dermal) exposure to contaminants. Indeed, the most prevalent form of occupational illness is skin disease or dermatitis from contact with toxic or irritating substances. As well, every time a person goes for a swim (bathes), there is the possibility of skin exposure to waterborne microbes and chemical contaminants.

There are three main ways contaminants reach us through the skin: by handling contaminants or contaminated articles; from soil, including dust and airborne fibres; and from recreational water, or water used for baths and showers.

Handling Chemicals

Whenever someone handles pesticides, household chemicals, treated wood, or any of the various chemicals or chemically treated materials, there is some possibility of exposure. A chemical in any form – spray, liquid or solid – can reach a person through the skin. A person could be exposed to contaminants this way at work, but exposure may also occur at home or in many other situations.

Soil

Soil may become contaminated with toxic substances; when contaminated soil, dust or fibres come in contact with the skin, we are exposed to those contaminants. Pesticides are sprayed on fields, forests, lawns and golf courses; oils and asphalt are applied to roads and lots, and industrial and municipal waste dumps leak a variety of substances into the soil around them.

Soils may also be contaminated in less direct ways from exhaust from automobiles, particles of matter from industrial smokestacks, waste matter from mines, and deposits from acid rain.

Canadians spend a lot of time in and around the water. Maintaining a high quality of recreational water is important.

It is extremely hard to monitor how much we take in after being exposed to toxic substances from soil and dust. This problem has not been studied in depth and no standard approach has been devised for evaluating the risk.

The skin's exposure to soil varies according to whether the local climate is, for example, dusty, dry or windy, and to the amount of ground cover such as grass or snow, as well as to the season. Technically it is possible for the entire body to be exposed to toxic substances from soil. The body may also touch clothing that has previously been exposed. The length of time the skin is in contact with soil is a major factor in determining the level of exposure.

A more important factor, however, is the degree to which the contaminant is absorbed. This varies depending upon the nature of the contaminant and the skin's permeability. Skin can vary greatly in the amount to which it can be penetrated because its hydration (water content) may vary and because cosmetics such as creams or lotions may affect its absorbency.

Soil contamination results mainly from human activities, including the production of industrial and municipal waste, and the unwise use of agricultural chemicals such as pesticides. This type of contamination, although localized when identified, may cause long-term problems because of difficulties in removal. This is particularly true for contamination by some heavy metals.

A national program has been developed to reclaim contaminated sites (see Chapter Seven).

Recreational Water

In the summer, Canadians spend a lot of time in and around the water. We have an abundance of freshwater lakes and a coastline that rivals any other for spectacular beauty. Canadians are also lucky because our recreational water is generally very safe and is carefully monitored by provincial and municipal authorities in areas where there might be problems.

We are exposed to recreational water through the skin, eyes, nose, ears and mouth when we engage in such activities as swimming, water-skiing, windsurfing and even fishing. Because of this, maintaining a high quality of recreational water is an important public health issue. The most common risk to human health comes from micro-organisms such as bacteria and viruses.[21, 22]

When it rains, recreational waters may become contaminated by animal and human feces. Through run-off from the land and from poorly treated sewage, fecal waste is washed into lakes and rivers and can create major pollution when these waters are not able to flush the material out effectively. Run-off of storm water from some residential areas may affect nearby beaches or recreational water.

Although the most obvious way micro-organisms enter the body from recreational water is when a person accidentally swallows some of the water, breathing or skin contact should not be discounted as routes of exposure. Sensitive tissues such as eyes and ears or scraped

Recreational Water Quality Guidelines

The most important factor in safe recreational water is the microbiological quality. Therefore, the *Guidelines for Canadian Recreational Water Quality* recommend levels for certain micro-organisms. Because there are many kinds of micro-organisms in water, the guidelines suggest limits for organisms that act as efficient indicators or guides to water quality but are not necessarily harmful themselves. These select organisms are known as indicator organisms. The two most widely used indicator organisms are *E. coli* in fresh water, and enterococci in salt water.

E. coli is a bacterium commonly found in human and animal body waste. Its presence in recreational water shows that pathogenic, or disease-causing bacteria, are also present. The guidelines recommend that levels of *E. coli* not surpass 2 000 organisms per litre of water.[24]

In salt water, enterococci are the bacteria most commonly used as indicators of the presence of other disease-causing bacteria. Like *E. coli*, they are found in human and animal feces. Enterococci are better indicators than *E. coli* in salt water because they survive longer. The guidelines advise that recreational waters should not contain more than 350 enterococci per litre.[24]

While the guidelines set levels for only *E. coli* and enterococci, they do recommend testing for disease-causing bacteria if there is any evidence that they may be contaminating the water. Such bacteria include *Staphylococcus aureus*, which may cause boils or ear infections, and *Shigella*, which may cause diarrhea, vomiting, abdominal pain and fever.

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skin are particularly vulnerable to infection. "Swimmers' ear" is a bacterial infection that affects many people each year, and "swimmers' itch" is also a problem. It results from infection by a parasite, originating from infected snails living in shallow water. Stomach upset and respiratory illnesses similar to the common cold can also be caused from ingesting contaminated water.

The acidic balance of recreational water can have minor health effects too. If the water is too acidic or too alkaline, a person's eyes can become irritated. Because of this, the ***Guidelines for Canadian Recreational Water Quality*** have stipulated that for pleasant and healthy recreational water the measure of acidity, or pH balance, should be between 6.5 and 8.5. If a particular body of water has a low resistance to increases or decreases in pH (the buffering capacity of the water), the criteria for pH balance can be extended a little. The guidelines recommend that for water of this type, the pH balance can be between 5.0 and 9.0.

The water quality guidelines also take into account factors such as the clarity of the water and whether or not there are "nuisance organisms" – for example, algae and aquatic plants – in the recreational area. Temperature is considered, as is the presence of oil and grease. Some investigators have suggested that absorption of organic chemicals by a person's skin while the individual is bathing or swimming can be very high. However, because of a lack of sufficient scientific information, the guidelines make no recommendations about limits for these chemicals in recreational water.

Regulations concerning recreational water quality are a provincial and territorial responsibility. Therefore, decisions about whether to close beaches or post warnings to users of recreational waters are made by the medical health officer or other appropriate provincial or local authority according to the public health laws in that province or territory.[23]

Chapter Two
How Do Contaminants Affect Us?

Contaminants known to be harmful to human health are usually found in concentrations far below the level at which scientists consider them to be a risk to us. However, dramatic incidents of pollution, such as chemical spills, can pose an immediate health hazard.

We sometimes feel that the possibility of illness from contaminants in the environment looms larger and larger. But are we right? How exactly is our health affected?

Except in certain circumstances, contaminants known to be harmful to human health are usually found in concentrations far below the level at which scientists consider them to be a risk to us. The main exceptions are dramatic incidents of pollution such as nuclear accidents and chemical spills, and exposure involving personal choice as in smoking. There are, however, potentially harmful contaminants in the environment that we do know about, as well as many more for which the health effects, if any, are unknown or uncertain. Fortunately, efforts to reduce some types of contamination have been encouraging. For example, efforts to reduce air pollution in recent years have had a significant effect on emissions of some contaminants. The reduction of lead and its total ban in gasoline has, for example, cut down lead pollution from car exhaust fumes. In some cases, emissions are actually below what they were a few years ago; in others, the increase in levels has slowed considerably.[25]

In severe instances of pollution, such as those caused by a toxic chemical spill, the risk of harm to human health rises significantly. At these times, children, the elderly, and some chronically ill people are particularly at risk.[25]

Certain groups of people – those in jobs that expose them to a particular contaminant, for instance – may also face some health risks not common to the general population. The character of the Hatter in Lewis Carroll's *Alice's Adventures in Wonderland,* for example, may have had some basis in fact. People who manufactured hats in the nineteenth century were reputed to be eccentric, perhaps because mercury used in felt processing affected their nervous systems.[26]

As the previous example shows, in the case of a recognizable group of workers with a certain similar pattern of exposure, scientists can sometimes match the symptom to the cause. Often the problem is not easy to identify, though, and researchers may have an extraordinarily difficult time trying to pin down exactly which contaminant – or combinations of contaminants – produces a certain ill effect.[27]

A major problem in identifying the risks of particular contaminants is the influence of other factors. That is, individual contaminants may be relatively harmless by themselves but very toxic when combined with certain other elements. Researchers must often use sophisticated scientific methods of study to find the answers to such puzzles.

Chemical Interactions

When chemicals occur together in a particular environment they may have different toxic effects than if they occurred by themselves. If some interaction occurs between chemicals or, more correctly, when chemicals combine inside an organism, the degree of interaction may determine the magnitude of the effect on the organism. The three ways chemicals interact in this manner are synergism, promotion, and antagonism.

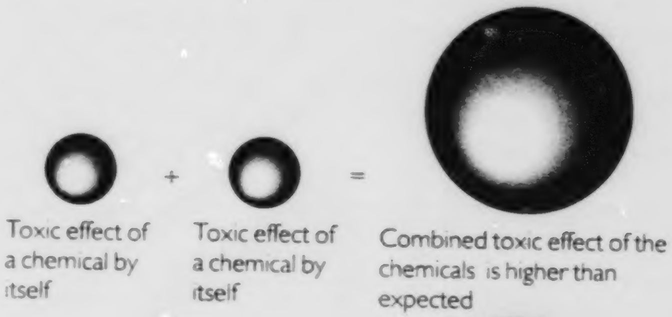
These various possible chemical interactions may make a great deal of difference to researchers attempting to determine the risks in certain environments, and to physicians or other health professionals trying to help their patients.

One widely used example of synergism is the combination of asbestos and cigarette smoke (see also "Asbestos" in Chapter Three). Studies have shown that before working conditions were improved, a person increased the chance of getting lung cancer by being an asbestos worker. However, asbestos workers who smoked – a case of two risks combined – were found to have a risk of lung cancer that was much greater than expected.[26]

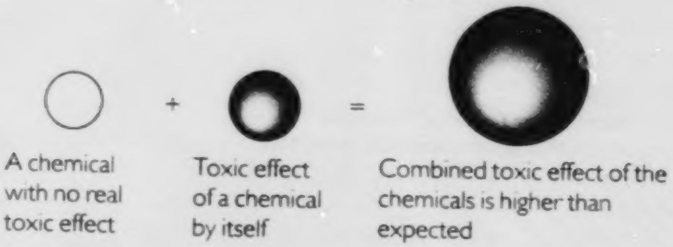
Most cases of promotion have been found in animal studies. For example, certain components of croton oil have been found to be potent promoters of skin tumours in mice exposed to certain carcinogens.

An example of antagonism is the effect of calcium on the absorption of lead by the body. When larger amounts of calcium are ingested, the body absorbs less lead. This is a good reason for physicians to be aware of their patients' intake of calcium, particularly in cities where environmental lead levels may be high.[28]

Synergism happens when the total toxic effect of two or more chemicals occurring together is much greater than what might be expected if their individual toxicities were added together.


+
=
Toxic effect of a chemical by itself
Toxic effect of a chemical by itself
Combined toxic effect of the chemicals is higher than expected

In **Promotion**, a chemical with no measurable toxic effect combines with a known toxic chemical and increases the toxicity of that chemical above what might be expected.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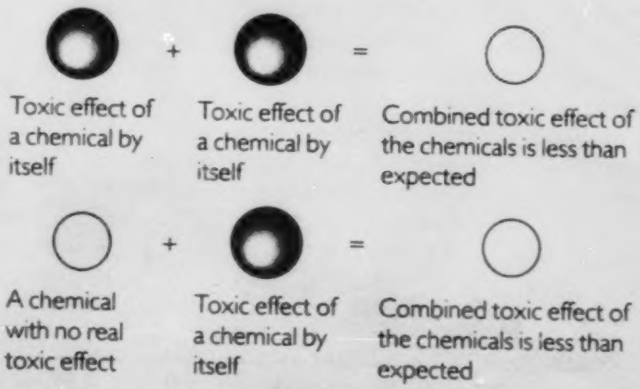
A chemical with no real toxic effect
Toxic effect of a chemical by itself
Combined toxic effect of the chemicals is higher than expected

In **Antagonism**, which is somewhat opposite to the other two types of chemical interaction, the sum of the toxic effects of two chemicals occurring together is less than what might be expected from their individual toxicities. Also, if a chemical with no notable toxicity combines with a toxic chemical, the toxicity may decrease.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Toxic effect of a chemical by itself
Toxic effect of a chemical by itself
Combined toxic effect of the chemicals is less than expected
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A chemical with no real toxic effect
Toxic effect of a chemical by itself
Combined toxic effect of the chemicals is less than expected

Information on Hazardous Materials in the Workplace

A national program established in 1988 is designed to provide employees with information about the hazardous materials they may work with. The Workplace Hazardous Materials Information System (WHMIS) was developed through the combined efforts of people in industry, labour and government who were concerned about safety and health problems related to hazardous materials in the workplace.

Under WHMIS, the responsibility for safety rests with suppliers, employers and workers. Suppliers must provide information about hazardous products by labelling them and by supplying data sheets that describe the hazards of materials.

Employers must ensure that labels are affixed to all hazardous materials, supply employees with data sheets on the safety of materials, and train employees to handle hazardous materials safely.

Workers must use the information available to them to handle hazardous products in a safe manner. Thanks to this information system, the exposure of employees to hazardous materials should decrease, thereby reducing work-related accidents, injuries and illnesses.[29]

The first investigations into the link between environment and health were studies relating to occupational exposure. A great number of the chemicals that now are recognized as contaminants in the environment have been, at some time, hazards in the workplace, causing illness to many workers over the years. Investigation of these health effects has resulted in exposure guidelines and safety standards.

It is difficult for researchers to generalize health effects that may result from relatively high levels of exposure on the job to low levels of contamination in the environment. Many factors are involved, such as the state of a person's health. As well, workers are consistently exposed to contaminants at the workplace while, at the same

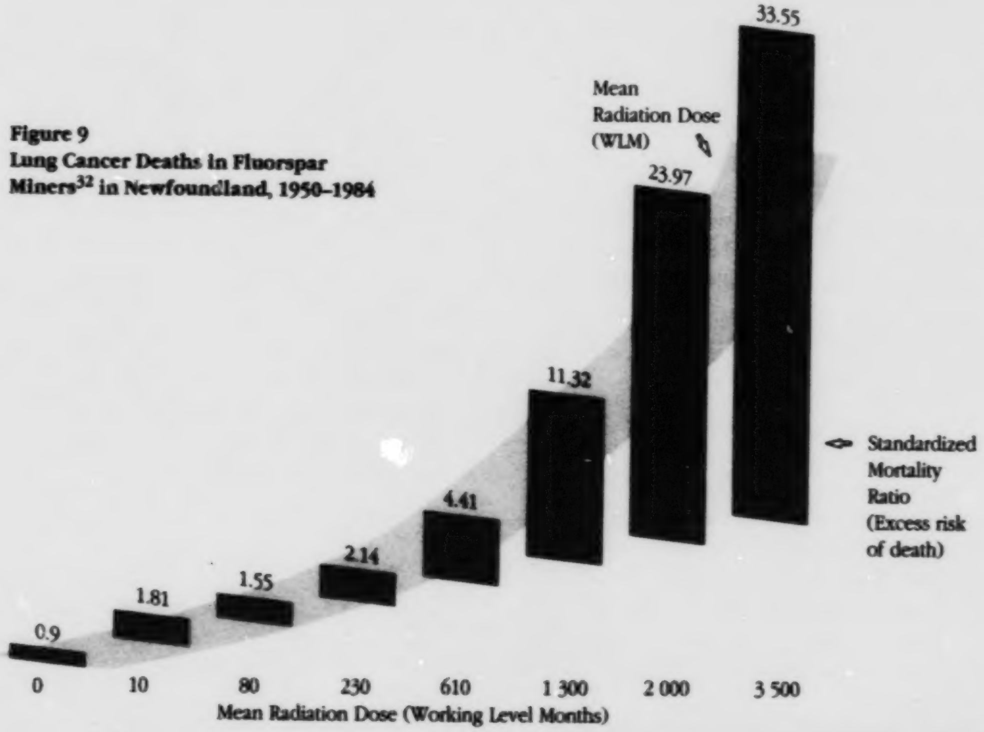


Figure 9
Lung Cancer Deaths in Fluorspar Miners[32] in Newfoundland, 1950–1984

time, possibly being protected from others present in the general environment. As a result, levels of exposure set for workers are often of limited use in protecting the general public.

Since the level of people's exposure to contaminants at home is usually lower than that at work – except for some hobbyists, or when there are accidents and toxic spills – scientists find it hard to determine the exact causes of environmental diseases. However, exposure to some substances may be higher in the home because much more time is spent there than at work.

Acute and Chronic Health Effects

Health effects can be divided roughly into two categories depending upon the type of exposure a person receives. If someone is subject to a single or short-term severe exposure to a harmful contaminant and has a severe reaction, both the exposure and the effect on the person's health are termed *acute*. On the other hand, a longer, lower-level exposure and its slowly developing health effects are called long-term or *chronic*.

The difference between the two types of exposure is dramatically illustrated by the body's reactions when exposed to varying degrees of radiation. When a person has an extremely high exposure to ionizing radiation, the effects are serious, even life threatening, and will occur shortly after the exposure. On the other hand, the effects of chronic exposure to low-level radiation – for example, uranium in the ground – are somewhat less obvious and may lead to the development of cancer many years later.

Ionizing radiation destroys cells as it passes through a person's body and, if the dose is high enough, too many cells are killed and the body cannot repair itself. At high radiation doses when large numbers of cells are killed, a person dies (see Chapter Six).

Lung Cancer and Radon Exposure

Radon is a radioactive gas that is found throughout the earth's crust. It occurs as a decay product of uranium and other radioactive elements. Radon itself presents little risk to human health, but it further decays into radon "daughters" or "progeny" which increase the risk of lung cancers. These radioactive decay products are found at high levels in various mines and ore-processing facilities.

In an attempt to measure this increased risk of lung cancer in miners and relate it to dose and other factors, researchers from Health and Welfare Canada studied a group of 1 772 workers employed between 1950 and 1978 at a fluorspar mine in St. Lawrence, Nfld. Fluorspar, or calcium fluoride, is a mineral used in making flux, a substance used to help make metals and minerals fuse together in welding.

The study sought not only to compare death rates between exposed and unexposed populations, but also to compare the degree of exposure to radiation to determine how it affected the rates of lung cancer.[32] In the 1950s, increasing deaths from lung cancer among the miners alerted health officials to a possible link to mining and cancer in this group. Later measurements were made that showed the air in the mine was contaminated by dangerous levels of radon and radon progeny.

After estimating radiation doses from air sampling records kept by the mine, the researchers could estimate lengths and levels of exposure based on workers' employment records. Also, the researchers used the Statistics Canada data base that contains information about causes of death.

Using the measurement of Working Level Months (WLM) – the estimated exposure to radon progeny a worker would receive in 170 hours in working conditions – the researchers determined rates of lung cancer for workers who had been exposed for various periods of time. Miners in the fluorspar mine in Newfoundland had a significantly increased risk of death from lung cancer; this risk was linked to the amount of radiation the miners were exposed to while working (see figure 9).[32]

In keeping with findings from other studies, this survey found that the lung cancers developed at some extended period after the first exposure. No lung cancer cases were noted in the first five years that the miners were underground. In the next five-year period, an excess of cancers began to appear, and this trend increased with time.

Many workers have been exposed to contaminants in the workplace. Often such groups are studied to determine the effects of environmental contaminants.

The health effects of long-term exposure to low doses of radiation are the subject of much controversy. Low-level radiation exposure has been linked to accelerated aging, the breakdown of the body's immune system, and cancer. While in some cases scientists do not agree on why or how health is affected, radiation is a known cancer-causing agent (carcinogen).[30, 31]

Researchers can have difficulty determining what health effects result from chronic exposure and what would normally occur in the course of an illness. They cannot compare the effects following acute exposure with those of chronic exposure because these are so different.

Nevertheless, scientists have identified several categories of environmental hazards as well as many chronic effects on health from prolonged low-level exposure.

Environmentally Related Health Problems

A whole range of diseases have been experimentally linked to environmental factors: respiratory diseases, skin or eye problems caused by irritants or ultraviolet light, systemic poisoning (including damage to the nervous system), and genetic changes. In addition, there are indications that some people who are especially sensitive to substances in the environment may develop allergies or many other health problems.

Respiratory Diseases

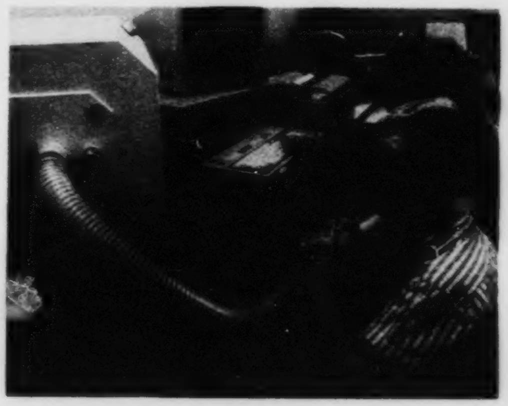
Contaminants that cause respiratory diseases can be grouped into four categories: irritants, fibres, asphyxiants, and carcinogens. As well, contaminants in the environment may affect people who already have diseases such as asthma.

Respiratory irritants, fibrotic agents and possibly even asphyxiants all play a role in certain chronic respiratory ailments. A condition called either "chronic obstructive pulmonary disease" or "chronic obstructive lung disease" includes many chronic respiratory conditions, including emphysema, asthma and chronic bronchitis.

Again, investigators are not sure if pollutants cause the disease or merely make it worse. However, there is definitely a relationship between certain air pollutants and the symptoms of a sufferer. Researchers suspect that these pollutants contribute to infectious respiratory diseases such as pneumonia, probably by reducing resistance to infection.[26]

Irritants

Respiratory irritants – such as ozone, sulphur dioxide, nitrogen dioxide and particulate matter, recognized as major air pollutants – are found particularly in urban areas. They can contribute to rhinitis, an inflammation of mucous membranes in the nose, and bronchitis, a similar inflammation of bronchial membranes. Other irritants, such as formaldehyde, can be found in the workplace or home.[26] If a person is already suffering from a respiratory ailment such as bronchial asthma, irritants can make the condition worse or even cause an attack.



The effects of pollution on lungs can be tested by using equipment such as a respirometer.

A Study of Mesothelioma

Since 1985, researchers at McGill University have been studying mesothelioma, a rare form of cancer that affects the lining of the lungs and is usually associated with exposure to asbestos.

The researchers have been studying residents of the asbestos mining towns of Thetford Mines and Asbestos in Eastern Quebec. Their research has uncovered preliminary evidence that a substance known as tremolite, a useless mineral in asbestos rock, may be the cause of mesothelioma. Previously, it was thought that chrysotile, the main asbestos component, caused the disease. The researchers found that most of the people they studied had as much or more tremolite in their lungs as chrysotile.[37]

The researchers also wanted to know whether mesothelioma is limited just to asbestos workers or can also be found in residents who live near the mines but who do not work there. Research showed that while tremolite was present in the lungs of some of the residents of Thetford Mines who did not work with asbestos, almost all cases of mesothelioma were confined to workers in asbestos mines. The only exceptions were from several years ago, when wives of asbestos workers were exposed to asbestos dust on their husbands' clothes. Workers are now required to change their clothes before returning home.[37]

Fibres and Dust

Fibrous substances such as asbestos and coal dust can lodge in the lung and, because the body has a very limited ability to cleanse itself of them, they contribute to respiratory diseases and can cause emphysema and cancer. Diseases from fibrous substances are usually caused when people are exposed on the job.

Coal dust, for example, causes anthracosis (black lung); cotton dust causes byssinosis (brown lung); cellulose from sugar cane causes bagassosis; and asbestos can lead to asbestosis. People working in the industries using or producing coal, cotton, sugar cane or asbestos have a higher chance of contracting the associated respiratory diseases than most other people.

Asphyxiants

Asphyxiants are gases that block oxygen exchange in the lungs. The most common such asphyxiant, carbon monoxide, comes mainly from automobile exhaust, but is also found in some workplaces. It can also be given off by faulty home heaters and gas stoves. When inhaled, carbon monoxide binds with hemoglobin (a blood component in the lungs that carries oxygen to the tissues to maintain life) preventing the normal exchange of oxygen; after very high exposures, this can cause neurological damage or death. Some studies indicate that increases of carbon monoxide during severe episodes of air pollution also bring on attacks of angina pectoris in people who have heart trouble.

Carcinogens

Many of the known cancer-causing agents affect the respiratory system. A number of ingredients in cigarette smoke are well-known carcinogens in this category, and can cause cancers outside the respiratory system as well. When combined, some of these carcinogens are even more deadly than the sum of their individual effects.[33, 34, 35]

Some fibres are also now recognized as carcinogens. In fact, the cause-and-effect link between certain fibres and cancer is sometimes considered to be definite; it is unusual to be this sure of the cause of environmental diseases. For example, some researchers suggest that mesothelioma, a rare cancer affecting the lining of the lungs and abdomen, may only affect asbestos workers and their families. Apparently it can result from minimal exposure to asbestos fibres.[36, 37]

Skin or Eye Problems

Ultraviolet light and irritants of various sorts may also cause serious skin or eye problems. Overexposure to ultraviolet light can lead to skin cancer and can cause eye inflammations and other problems. Usually an exposure that is severe enough to cause a skin or eye reaction from irritants occurs at the workplace; as well, air pollutants may cause some eye discomfort during temperature inversions when pollutants are trapped and concentrated near the ground.

Occasionally a chemical spill or similar environmental crisis can affect the general population. An industrial accident in 1976, for example, contaminated the area in and around Seveso, Italy, with dioxins and other chemicals. Many health effects of that chemical were investigated after the spill, but researchers could not determine individual risk factors such as how long and how much a person had been exposed. The most notable and consistent effect on health from this spill was chloracne, a skin condition characterized by blackheads and other skin lesions.[38]

Other chemical products and by-products of manufacturing are known to be irritants. For instance, many pesticides are highly irritating to the skin, and direct contact with sulphuric acid, a by-product in many manufacturing processes, can cause serious rashes and eye problems. Sulphuric acid is also created during episodes of major pollution when fog is present, and is found in acid rain. In both situations, sulphur oxides, water vapour and sunlight react to form sulphuric acid. Generally it is not strong enough to noticeably affect the eyes.

Lead Absorption by Children

There has been special concern over the effects of lead in children. Children absorb lead into their bodies more readily than adults, and high exposure to lead may negatively affect a child's intelligence and behaviour.

Children may be exposed to lead through a number of sources: outdoor air in urban areas may contain high levels of lead; areas near smelters may be contaminated with lead; homes may contain lead paint; and, in households where a person lives who works with lead, there may be increased amounts of lead dust.

A number of studies have been undertaken in recent years to test the levels of lead in children. One such study was conducted in the Quebec community of Murdochville, which is centred around a copper smelter, where lead is released into the air.[41]

The study compared four groups of children between the ages of two and 12:
Group A – children who lived near the smelter and had a parent working there;
Group B – children who lived near the smelter but did not have a parent working there;
Group C – children who did not live near the smelter but had a parent working there; and
Group D – a "control group" of children who lived 200 kilometres from the smelter.

Exposure group	*Average blood lead levels in micrograms per litre*
A	166
B	163
C	112
D	91

The study tested the levels of lead in the blood of each of these groups. Researchers found that children who were exposed to lead in their environments had significantly higher levels of lead in their blood than children who were not exposed. Children who both lived near the smelter and had a parent working there had the highest levels of lead in their blood. Children who lived near the smelter had the second highest levels, and those with a parent working in the plant had the third highest level. Children from the control group had the lowest levels.[41]

The researchers concluded that living near a copper smelter or living in the same household with a person employed in that smelter can result in an exposure that causes significant increases in blood lead levels.[41]

Poisoning

Poisoning from environmental contaminants, while infrequent, is possible. Certain agents common in the environment can cause either acute or chronic poisoning.

While extreme cases of poisoning – usually occurring when a person directly ingests a toxic or poisonous material – may cause death, lesser exposures will interrupt body processes or damage the body. Toxins may affect one place in the body or several sites or systems.[39]

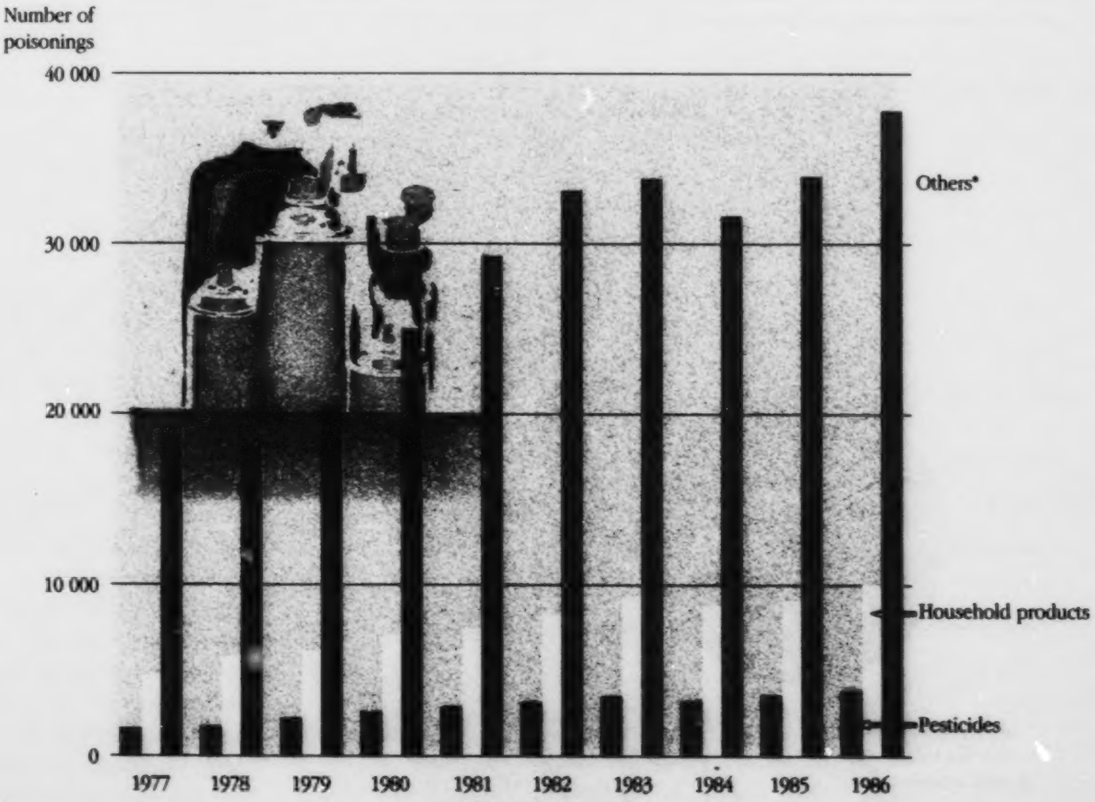
Some substances manufactured to be used as poisons, such as insecticides and herbicides, may be detrimental to people working improperly with them, or using them indiscriminately at home.

Many heavy metals such as lead, mercury and cadmium are also poisons. Arsenic, while not technically classed as a heavy metal, also falls into this category. The detailed effects of these poisons in the human body vary considerably, but all may affect the nervous system. People working or living in certain environments may be particularly exposed. For instance, researchers have found higher levels of lead in the blood of children living in cities.[40]

The number of reports of poisonings from non-drug chemicals has increased. Two of the environmental contaminants of health significance, pesticides and household products, contribute to this overall trend (see figure 10).[42] However, it is important to note that this trend may be a result of increased reporting rather than an actual increase in poisonings.

Chronic exposure to low levels of environmental contaminants has recognized effects in growing children. Many studies indicate that children exposed to lead at relatively low levels, for example, may experience developmental problems. There are, however, varying opinions about the extent to which chronic exposure affects learning and behaviour.[43] Chronic exposure to high levels of any heavy metal may have serious consequences.

Figure 10
Non-Drug Related Poisoning Cases in Canada[42]



* The category "Others", includes cosmetics, hydrocarbons, gases, vapours, hobby materials, glues, toys, plants and foods.

Extreme problems in development as well as interruption of normal nerve and motor responses such as eye and hand co-ordination are typical.

Fluoride is another potential poison, and presents an interesting case. It is a naturally occurring element that is also released by some industrial processes. At low levels, fluoride is beneficial to human health; it increases the resistance of tooth enamel to acids that cause cavities. Because of this, many municipalities add fluoride to their water supplies.[44] In high concentrations, though, it may have harmful effects. Therefore, municipalities carefully regulate water supplies, keeping fluoride concentration at acceptable levels set by the *Guidelines for Canadian Drinking Water Quality*.[44]

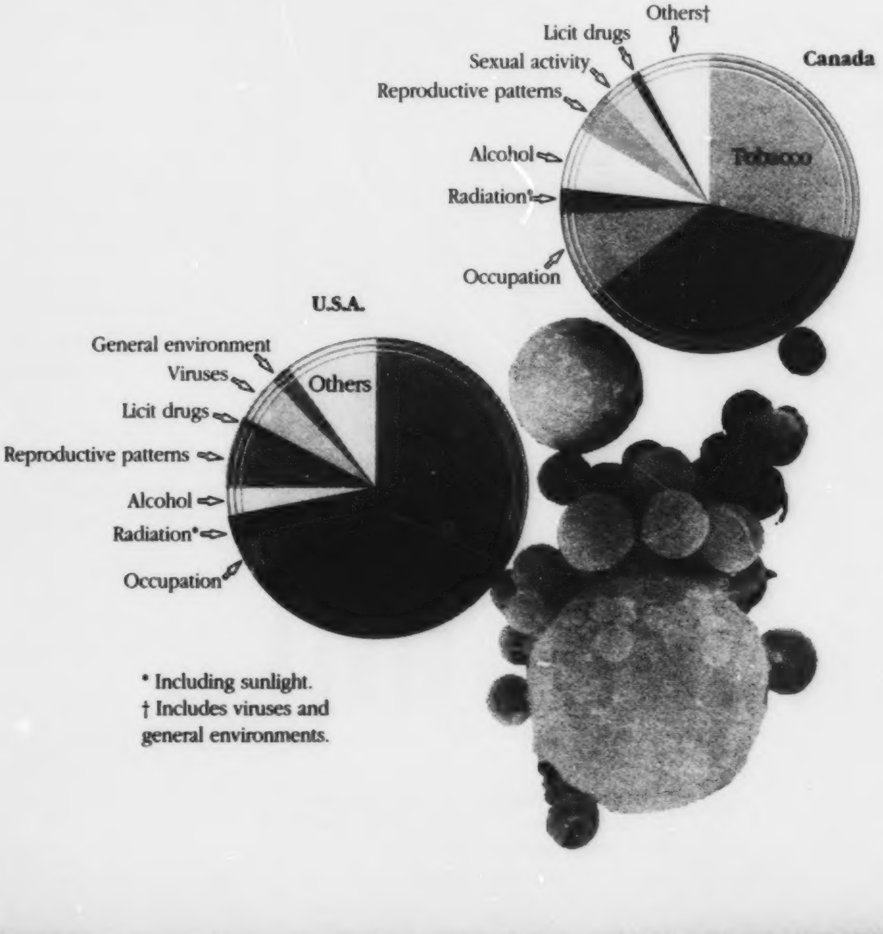
Genetic Change

Some environmental contaminants may have a part in altering genetic material or preventing normal cell development or regeneration.

One type of agent that causes genetic change in an organism is a mutagen; it may cause birth defects or cancer. Certain pollutants in the environment (such as cadmium and ionizing radiation) are mutagens. Teratogens are agents that cause birth defects, and carcinogens are agents that cause cancer. Teratogens are relatively few in number, and usually do not appear in concentrations sufficient to do serious damage. Radiation, cadmium, alcohol, and tobacco smoke, among others, act as teratogens in high doses.

The presence of chemical carcinogens in the environment is at the centre of public discussion on how environmental contaminants affect human health. However, since the number of known cancer-causing agents is very small, some people argue that the attention paid to carcinogens is disproportionate in light of other important environmental issues. In fact, it has been estimated that general environmental factors, excluding sunlight, account for approximately two percent of cancer deaths (see figure 11).

Figure 11
Estimates of the Percentage of Cancer Deaths in Canada and the United States from Known Causal Factors[45, 46, 47]



* Including sunlight.
† Includes viruses and general environments.

Allergies

Our bodies are also significantly disrupted by allergens, (substances causing allergic reactions). The reactions may vary significantly from person to person but in some cases they may be debilitating.

A number of materials may trigger allergic responses in certain people. These include bacteria, fungi, pollens, dust, bee stings, and penicillin, as well as some foods and food additives. Some people develop allergic-like reactions to high concentrations of chemicals in their work or living environment.

Environmental Sensitivity
There has been growing concern about the unusual sensitivity some people display to low levels of chemicals and other substances both indoors and outdoors. This rare syndrome has become known as environmental sensitivity, but is also called by other names: multiple chemical sensitivities, hypersensitivity, twentieth-century illness, and universal allergy.

The symptoms of this condition could result from any number of causes and vary from person to person, so there is no standard clinical description of the illness. Some symptoms are fairly subjective and include unexplained weakness, generalized anxiety, fatigue, tremor and sweating, depression, palpitations, headache, bloating, gas, intolerance to food, and muscle and chest pains. Other symptoms are more objective: intolerance to medication and alcohol, excessive sneezing, eye-watering, coughing, skin rashes, and constipation.[48] In many cases these physical symptoms may also result in social and psychological stresses.

Since such symptoms are hard to measure, the identification and treatment of this condition are also difficult. Recognizing this, participants in a workshop on the topic recommended that the treatment of environmental sensitivity should be considered on a case-by-case basis. The workshop in May 1990 was organized by Health and Welfare Canada's Laboratory Centre for Disease Control.[49] Other recommendations included the need to educate the public and professionals about environmental sensitivity, as well as the need for health care professionals to acknowledge the disabilities associated with the syndrome, and to convey their compassion for people afflicted with it.

There is no consensus on the physical triggers or irritants that provoke sensitivity, although possible triggers in the home include tobacco smoke, food ingredients and foods themselves – nuts, for example – as well as perfumes, formaldehyde, gases given off by carpets, house dust, mould, and animal dander. One theory is that the triggering of environmental sensitivities is similar to an allergic reaction, where symptoms result from exposure to particular substances or environments. Indeed, sensitive people may react to uncommonly small doses of a given substance.[49] In an attempt to identify problem substances, researchers test people with extreme environmental sensitivity in special environmental care units designed to remove as many triggers from their surroundings as possible. Suspected triggers and irritants are then introduced in a controlled manner to test for reactions.[48]

Environmentally sensitive people may experience adverse reactions either through a single exposure to an irritant or chemical or prolonged low-level exposure. For an irritant to trigger the symptoms of sensitivity, it must be absorbed by the skin, lungs or stomach.

An example of how someone can become sensitized is the occasional person who has been exposed to a chemical spill on the job and subsequently develops pneumonia. Although a later X-ray of the person's chest shows clear lungs, shortness of breath and chest pains may increase. At home, the worker feels worse if she or he smells chemicals. When the worker is back on the job and again exposed to fumes, acute symptoms return. The person now is sensitized to react to even small exposures to the same or a related substance.

Most environmentally sensitive people report improvement when they adopt lifestyle changes that enable them to have clean air, clean water and foods low in chemicals. They should try to avoid any substance identified as triggering their condition. Generally, factors that should be controlled include household chemicals, cigarette smoke, fumes, changes in temperature and humidity, dust and dirt from heating and cooling systems, and mould and mildew. Some sensitive people respond well when they live in special housing units that have very low levels of airborne pollutants.

Chapter Three
Metals, Minerals and Air Pollutants

Since ancient times volcanoes have been a dramatic example of how contaminants can enter the environment. Clouds of poisonous smoke and lava containing metals and minerals are quickly released into the surrounding countryside. However, there are other more subtle ways contaminants can enter the environment from natural and artificial sources (see figure 12).

One of the natural ways in which metals, minerals and gases enter the environment is through volcanic activity such as the eruption May 18, 1980 at Mount St. Helens in the U.S.

Heavy Metals

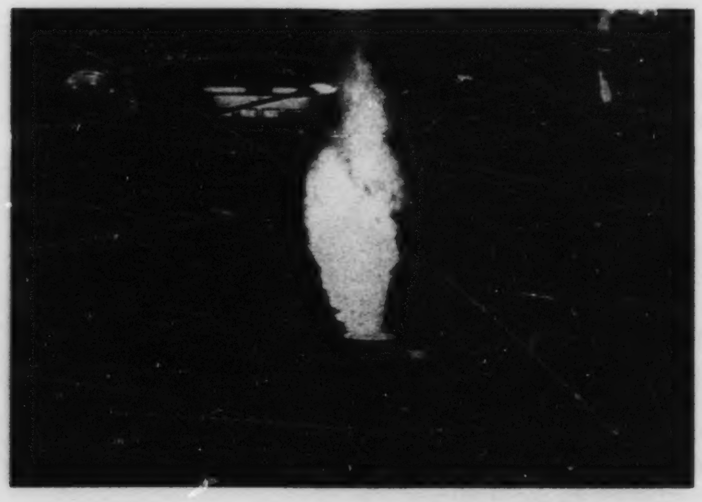
The major contributors to increased levels of heavy metals in the environment are industrial activities and the use of products by the public. Burning fossil fuels such as coal is another way in which many metals are released into the air. While all metals are toxic, particularly to the nervous system and kidneys, some heavy metals – mercury, lead, cadmium – are the worst. A person can become exposed to them by breathing, eating and, to a much lesser extent, by absorption through the skin.

Exposure

People are liable to inhale heavy metals directly in certain work situations, such as welding. Although incinerators release a significant amount of metals as combustion products, the concentrations are rarely high enough to pose an airborne health hazard. Metals do end up being deposited on vegetation, however.

Drinking water is usually a secondary way that heavy metals are ingested. Acid rain may wash metals that are soluble in acid – such as magnesium, lead, nickel, cadmium and mercury – from the ground. Since heavy metals concentrate in the food chain, some may be particularly concentrated in certain foods, for example, mercury in fish and food animals. Cadmium is found in higher concentrations in the kidneys and liver of certain animals, and in some shellfish.

Heavy metals on dust and dirt can be ingested by children who may suck their fingers and put toys in their mouths. Lead-based paints have been a problem. In older



Heavy metals can be released into the environment during certain manufacturing processes. Often worker exposure to such contaminants is higher than the general public's exposure.

buildings, paint chips may be around for children to put in their mouths. Children have also chewed toys and furniture painted with lead-based paints. Consequently, the federal Hazardous Products Act now restricts the availability of these paints.

Absorption

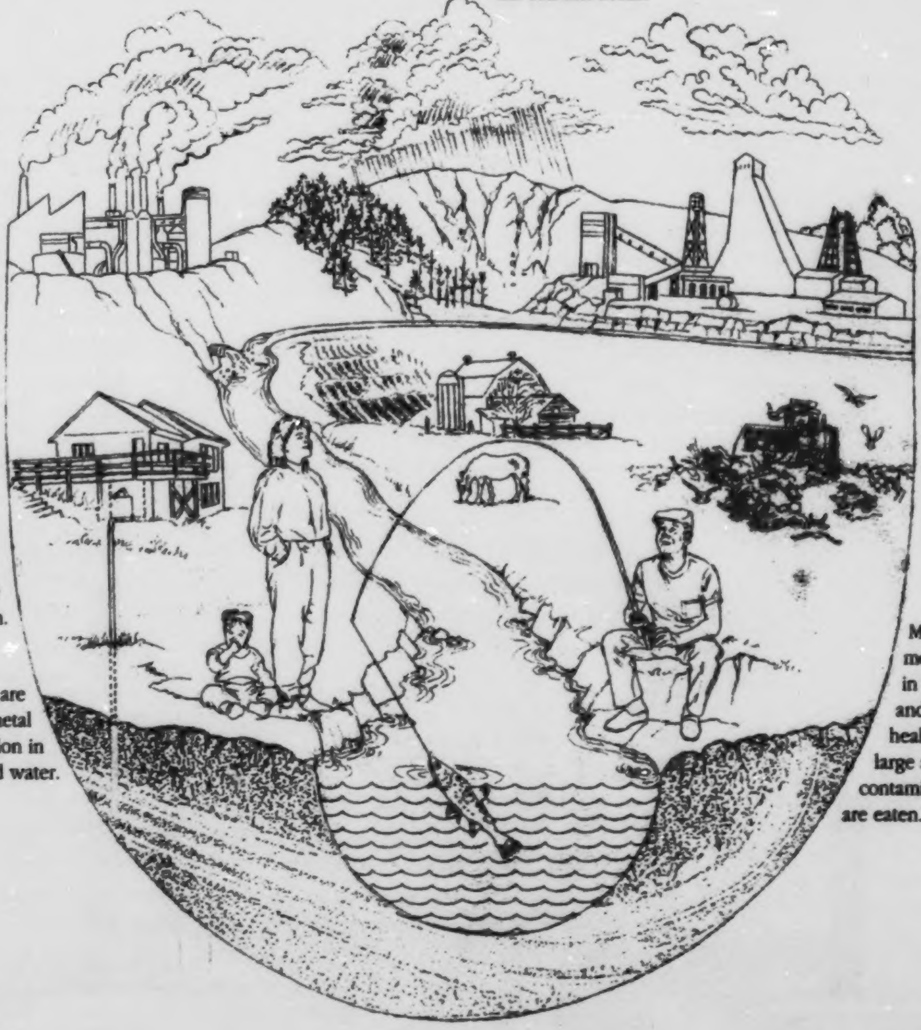
Different forms of the same heavy metal can vary significantly in their bioavailability (the ability to be absorbed by the body). Because of this, different forms can also vary in toxicity. For instance, inorganic or metallic mercury is less toxic than organic methylmercury and is absorbed much more readily by the body.

Chemical interactions may affect absorption as well – for example, lead absorption is increased if a person's diet is deficient in calcium or iron. Absorption is greater if a person has been fasting, and it may also be greater in pregnant women or nursing mothers. The most sensitive group of all are newborns because their bodies have not yet developed mechanisms to rid themselves of heavy metals.[50]

Some Serious Contaminants

As mentioned previously, three metals stand out as serious toxics: mercury, lead and cadmium. Arsenic, which is considered a metal but not a heavy metal, is included here because its toxic effects are as serious as those of heavy metals. Aluminum is also

Figure 12
The Release of Metals into the Environment



Acid rain helps to dissolve metals such as aluminum that occur naturally in the soil and rocks.

Some industrial activities, such as burning fossil fuels or discharging waste metals into effluents, are major contributors to metal contamination.

Mining activities can result in metals such as mercury, arsenic and lead entering lakes and streams.

Lead solder in pipes can result in lead in drinking water.

Metals from discarded consumer products (such as lead and cadmium from batteries) can be leached into ground water.

Heavy metals from the air, deposited on the soil, can be eaten by children.

Metals such as mercury accumulate in the food chain and can be a serious health problem if large amounts of contaminated fish are eaten.

Private wells are susceptible to metal contamination in ground water.

Mercury Levels

Many fish and sea mammals throughout the world may be contaminated with methylmercury. In the North, this contaminant is believed to be a chemical residue from industrial activities – a residue that has travelled to the Arctic through ocean currents and air movement. In other parts of Canada, methylmercury comes from natural sources as well as industrial activities. A major source of methylmercury in parts of Canada results from extensive flooding of land. The inorganic mercury is converted to methylmercury by submerged micro-organisms.

The presence of methylmercury in the food chain is a potentially serious problem for many aboriginal people who rely extensively on traditional foods for subsistence. Health and Welfare Canada has set up programs to study and monitor Native people's exposure to mercury. For example, between 1971 and 1978, 35 683 blood and hair tests for mercury levels were carried out in 350 communities. "At risk" levels were found in residents of 43 communities and constituted 2.5 percent of the total results. These levels were predominantly found in Quebec, Ontario and the Northwest Territories. However, "at risk" levels were found in individuals from all parts of Canada, except the Yukon and the Maritime provinces.[52]

The researchers concluded that mercury levels found in some individuals constituted a health risk. Some symptoms of mild methylmercury poisoning are general, vague, and shared by other diseases. Thus these types of symptoms cannot be linked exclusively to methylmercury poisoning. No cases of severe methylmercury poisoning (Minimata Disease) have been reported in Canada.[52]

During the study period, 1971 to 1978, scientists were particularly concerned about the possibility of prenatal exposure to methylmercury. A total of 520 maternal blood samples and 739 from infant umbilical cords were analyzed. All maternal levels were below 100 parts per billion – the maximum level at which no adverse effects are expected. The range of infant levels, in keeping with the findings elsewhere in the world, was greater, and included four results that were over 100 parts per billion. The researchers noted that while no clinical abnormalities had been detected, there was the possibility of more subtle developmental effects.[52] This has yet to be confirmed.

The monitoring of mercury levels in blood and hair continues today in areas of concern in Quebec, Manitoba, Ontario and the Northwest Territories. Health and Welfare Canada recommends that a balance be found between traditional Indian and Inuit foods, which can provide an excellent source of protein in the form of fish and sea mammals, and the potential danger to health due to high mercury levels in that food source. It also recommends (in certain areas only) that certain types of fish with generally low levels of mercury – that is, suckers and white fish – be favoured over those with high levels, such as lake trout. Officials also suggest that pregnant women in areas of concern should not consume large quantities of fish.[123]

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included. The amount of any of these metals that a person takes into the body determines the seriousness of their effects.

Mercury

People are exposed to mercury largely through the food chain, for example, by consuming fish that are contaminated by mercury. However, workers in certain occupations may inhale air containing mercury vapour. At high enough concentrations, this vapour may cause lung irritation and destruction of lung tissue, and will eventually cause central-nervous-system disorders.

As already mentioned, there are two forms of mercury: inorganic (metallic mercury) and organic mercury (methylmercury) which is more toxic. Once metallic mercury is absorbed, however, some of it is converted to methyl-mercury, so its effects cannot be discounted: it is still a serious contaminant.

When organic mercury (methylmercury) is ingested, it rapidly enters the bloodstream and is distributed throughout the body. Certain organs, particularly the liver and kidneys, accumulate more of it than others. The metal is more slowly accumulated in the brain, where it will have its most alarming effects if it is present in sufficient quantities.

The brain's sensory, visual, auditory and co-ordinating functions are affected in extreme circumstances. A developing fetus may be affected in a more generalized way; possible effects include retarded physical growth and co-ordination, and cerebral palsy. The effects of low doses of methylmercury on a fetus may be very subtle, possibly lowering the development of intellect, co-ordination and behaviour.[51]

Lead

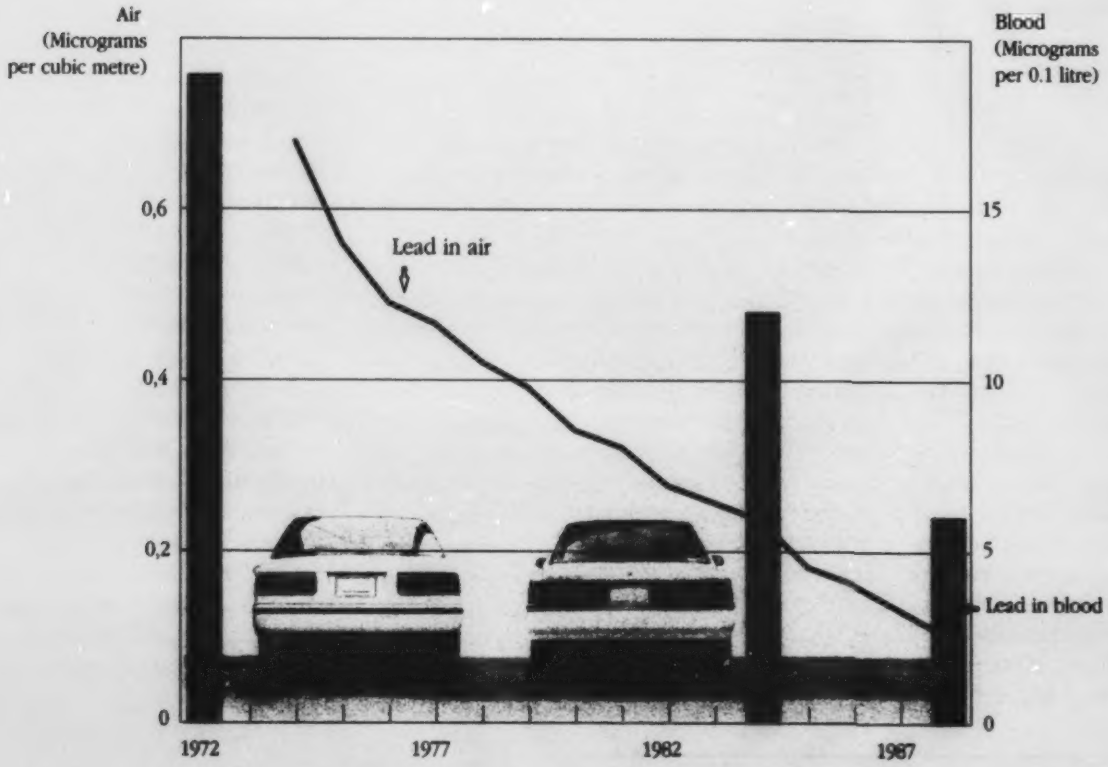
Since the Industrial Revolution, concentrations of lead in the environment have steadily increased, most dramatically since the 1920s, when lead compounds were added to automobile gasoline and lead automobile batteries were introduced. Wastes in landfills account for the largest percentage of lead discharge, but lead emitted into the air becomes more widely dispersed.[54]

While exposure to lead may be influenced by many factors, a survey of blood levels conducted by the World Health Organization between 1979 and 1981 recorded the lowest levels in Tokyo, which has had lead-free gasoline since 1976. The highest levels were recorded in Mexico City, where gasoline had the highest lead content.[55] Gasoline available at gas stations in Canada is now free of lead.[25]

Lead emissions in Canada have steadily declined over the last decade. The lead content of gasoline was first regulated in 1976 and any addition of lead to gasoline was prohibited after December 1, 1990.

Because lead is so prevalent in the environment, it can contaminate food – the greatest source of exposure for most people – in many ways. For instance, airborne lead can be deposited directly onto crops or be absorbed by plants from the soil. Lead has been used to solder cans in which food is sold. Also, lead-based glaze on ceramics can contaminate food. Although regulations in Canada make this a very unlikely source of lead contamination, pottery purchased in foreign countries may be questionable.[56]

Figure 13
Lead in the Atmosphere and in Children's Blood[58]



Lead solder can affect drinking water in older or very new homes, but the overall threat of lead content in drinking water is considered very low in Canada. To ensure that it remains so, the maximum acceptable concentration of lead has recently been reduced to 0.01 milligrams per litre in the *Guidelines for Canadian Drinking Water Quality*.[57] Workplace exposures to lead in battery-manufacturing plants have been a major source for some workers. Removal of old lead-containing paint during renovations can be an important source of lead indoors.

When lead is taken into the body, it is circulated in the blood and deposited in bone and other tissues. As with mercury, lead absorption in the body can vary. It is greatly increased after a person fasts and when calcium and phosphorous intake is low. Short-term exposure to high levels of lead may cause a person to have a metallic taste in the mouth, abdominal pain, vomiting, diarrhea, and convulsions; such exposure may lead to a coma or even death. However, such serious lead poisoning is very unusual.[54]

The amount of lead in the blood of children is, to a large extent, due to the lead in the atmosphere (and its deposit on land) from the use of lead in gasoline. As atmospheric lead is decreasing dramatically across Canada, so too are the blood-lead concentrations in children[25] (see figure 13). Lead gets into children's systems in the following proportions: 3 percent directly from the air, 53 percent from food, 40 percent from dust and dirt, and 4 percent from water.[58]

The current action level in Canada – at which some intervention is necessary if lead is in the blood – is 25 micrograms per decilitre. This level is being reviewed by the Federal/Provincial Advisory Committee on Environmental and Occupational Health.

Chronic exposure to lead at significant levels may produce generalized but serious symptoms. The most common first symptom is anemia. Lead exposure has also been linked to the impairment of many nervous-system functions, including mental function, eye and hand coordination, memory, and attention span.[53] A person may also have abdominal pain, lack of appetite, and constipation as well as fatigue, sleeplessness, irritability and headaches. Workers regularly exposed to elevated levels of lead may suffer kidney problems.

Children and developing fetuses are at much higher risk than the general population when it comes to health effects of exposure to

Lead Levels in the Blood of Ontario Children

Many studies have investigated the levels of lead in the blood of children living near a known source of lead emissions. Until recently, few studies have been done to test the levels of lead in children who are not exposed to such a specific source of lead emissions. In 1984, however, the Ontario government undertook a pioneering study to investigate the levels of lead in children across Ontario.[40] The study had two purposes: to determine the blood lead levels in Ontario children, and to identify the particular factors that might contribute to these levels.

Researchers tested 1 315 children age seven and younger from urban, suburban and rural Ontario. Urban children had the highest average levels of lead in their blood, followed by suburban children and rural children. Of the 1 315 children, 54 were at or above the "alert level" of 20 micrograms per decilitre. The proportion of children above the alert level did not differ significantly between urban, suburban and rural children.[40]

The researchers calculated those factors that contributed most to the higher levels of lead in the children's blood. They found that high levels of lead in air and soil, traffic density, and the presence of lead additives in gasoline were directly related to higher levels of lead in the children's blood. Aside from these environmental factors, other factors included the child's gender, socio-economic status and age.[40]

The researchers concluded that in this study, lead additives in gasoline – a major contributor to lead in air – appear to be the most significant single environmental factor determining the levels of lead in children's blood.[40]

People involved in certain arts and crafts activities can be exposed to metallic contaminants unless adequate precautions, such as proper ventillation, are taken.

lead. Children absorb 50 percent of the lead they ingest, while adults only absorb 10 percent. Recently, some researchers have found that exposure to relatively low levels of lead before birth or during infancy and early childhood may impair a child's intellectual development or hearing, cause behavioural problems, and result in smaller body size.

Although these findings are not conclusive, the possible impact of lead exposure on young children is still of concern in Canada, and is being studied by scientists at Health and Welfare Canada.

Cadmium

Cadmium is a relatively rare element that occurs naturally in the earth's crust. It is often associated in its natural state with zinc, copper and lead ores. Since people have used these ores for centuries, cadmium contamination is not new. However, it is only in relatively recent times that useful applications of cadmium itself have increased the likelihood of cadmium pollution.

Cadmium is used primarily in electroplating other metals or alloys to protect them against corrosion. As well, it is used extensively in producing alloys, solders, low-cadmium copper and stabilizers for plastics. Cadmium is used in lesser amounts in fungicides, control rods and shields for nuclear reactors, television picture-tubes, nickel cadmium batteries, motor oils, and rubber.

Industrial and municipal wastes are the major sources of cadmium pollution; heavily industrialized cities – especially those with smelters for nickel or copper – have the highest concentrations of cadmium in air.

People generally absorb cadmium by eating food that contains it, such as vegetables grown in contaminated soil. They usually absorb negligible amounts by breathing or through the skin. Cadmium is present in tobacco smoke, however, so a person's exposure is increased by smoking.

Once taken into the body, cadmium is, like the other heavy metals, distributed through the bloodstream. It accumulates and is concentrated in the kidneys and liver. Cadmium differs significantly from mercury and lead, however, because less of it crosses the placental barrier between mother and developing fetus. Therefore, typical maternal exposures to cadmium are thought not to be harmful to the unborn child.

Short-term exposures to high levels of cadmium may result in damage to a person's lungs along with difficulty in breathing, headaches, nausea, vomiting, chills, weakness and diarrhea. Chronic exposure has been associated with kidney damage and the lung disease emphysema, while lesser chronic exposure may cause fatigue, weight loss, abdominal pain, nausea and coughing. Animal studies have shown that high levels of cadmium can cause birth defects, and the element is considered to be a probable cause of cancer in humans. The effects of cadmium exposure may be reduced by calcium, protein, vitamin D, zinc, selenium and sex hormones.

Arsenic

Arsenic is a widely distributed element in the earth's crust. It is used in many industrial processes and is also associated with copper, lead, gold, silver and antimony ores. Arsenic occurs naturally in ground water in some areas of Canada.

Industrial sources of arsenic include copper smelting, gold mining, and the production of pesticides and fossil fuels. Arsenic is used to make lead shot, glass, copper and bronze alloys, solders, and wood preservatives. Arsenic compounds have been used in a wide variety of drugs, although such usage has declined significantly in recent years. However, arsenic is still present in some drugs used to get rid of parasites.[59, 60]

Arsenic compounds from smelting and other industrial activities may be present in air and water, but people generally absorb them from food. While seafood may have high natural concentrations of arsenic, it is in a less toxic form than the arsenic in other foods. Wine and tobacco can contain arsenic if they are from areas of the world where arsenic-containing pesticides are still used.[60]

Once taken into the body, arsenic is distributed to the liver, kidneys, lungs, spleen and skin. Acute arsenic poisoning can cause nausea, vomiting, diarrhea, inflammation and ulceration of mucous membranes, and kidney damage. Other symptoms include abdominal pains, thirst, dizziness, dehydration, muscle cramps, delirium and convulsions. Death can occur in extreme cases of arsenic poisoning when the liver, kidneys and circulatory system are severely damaged. Also, arsenic may be dangerous to the central nervous systems.

Chronic poisoning from arsenic can cause loss of appetite and weight, stomach and intestinal problems, cirrhosis of the liver, and dermatitis. It has also been associated with increased risk of skin, lung, and liver cancer.

In areas where acid rain is a significant environmental problem, greater concentrations of metals have been reported in the waters of lakes and rivers. This happens because the higher acid level in the rain water helps to dissolve metals, including aluminum, from soil and rock.

Aluminum

Aluminum is the second most abundant naturally occurring element in the world (after silicon), and is the third most common element, making up between eight and nine percent of the earth's crust. Because of this, people in Canada and around the world are exposed to aluminum in the air and ingest it in water and food. Aluminum levels in the environment vary widely due to geological factors, soil acidity, and proximity to pollution sources.[61]

Our bodies have defence mechanisms that allow us to deal with normal levels of aluminum. When the kidneys function normally, aluminum taken into the body is eliminated before there are any harmful effects. However, we may be less able to handle larger quantities of this metal, particularly if it is in a form that is more readily absorbed and stored in the human body. Also, people with kidney problems cannot eliminate aluminum efficiently.[62, 63]

Some researchers believe that some people may be genetically better equipped to keep aluminum from building up in their bodies.[64] This is a matter of conjecture, since the processes by which the body picks up and deals with aluminum are still not completely known. Aluminum can be present in unusual quantities in body tissues; this is particularly true for accumulations in the brain.[63]

Most of the aluminum we take in comes from food – 96 percent of a person's daily intake of aluminum under normal circumstances.[62] Water contributes a mere 3.5 percent of our intake.

Aluminum occurs naturally in some foods at low concentrations, but the amount of aluminum may be increased by the addition of aluminum compounds to certain foods such as processed cheese, yogurt, desserts and beverages. Aluminum cookware, utensils and foil can also increase the aluminum content of foods, particularly acidic foods such as tomatoes.

Investigators and environmentalists have expressed concern that one of the more serious effects of acid rain on the ecosystem is to increase the amount of bioavailable aluminum. In areas where acid rain is a significant environmental problem, greater concentrations of metals have been reported in the waters of lakes and rivers. This happens because the higher acid level in the rain water helps to dissolve metals, including aluminum, from soil and rock. Aluminum concentrations (aluminum sulphate) in drinking water may also be increased by water treatment because alum is used in the process.[65, 62] Although it may be wise to minimize the aluminum in drinking water, no direct adverse health effects have been conclusively attributed to an increased quantity of aluminum in water.

Some researchers have tried to find out whether there is any relationship between aluminum in water and the occurrence of Alzheimer's disease, a degenerative brain disease.[66]

The federal-provincial subcommittee responsible for setting Canadian drinking water guidelines continues to review the possibility of including aluminum. The subcommittee is doing a complete review of aluminum and its relationship to human health.

As with many other contaminants, the workplace is the most likely environment for exposure to aluminum at levels that might be toxic. Case reports of an asthmatic syndrome in aluminum factory workers first appeared in Norwegian medical literature more than 50 years ago. Much more research is needed to confirm the relationship between such exposure and the occurrence of lung disease.[68]

Both clinical and experimental studies have shown that aluminum in very high concentrations in the body is a neurotoxin, (toxic substance acting on the nervous system). Behavioural changes and a deterioration of mental performance, including a loss of short-term memory, have followed exposure to high concentrations of aluminum. In addition, researchers have observed impaired visual and

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Aluminum and Alzheimer's Disease

The possibility of a link between aluminum and Alzheimer's disease was raised as early as 1965. Researchers observed damage to the brain tissue of laboratory animals exposed to aluminum salts introduced into the central nervous system.

Since that time, a number of studies have continued to explore the relationship between aluminum and Alzheimer's disease to determine if aluminum is actually the substance causing the disease, or if its presence in brain tissue comes about because of the disease.

Recently, in Ontario, a study of 222 localities compared the level of aluminum in both raw and treated water with the incidence of Alzheimer's disease as reported by hospital files. The findings indicated that, when data on raw water were used, no significant association could be made with the number of Alzheimer's patients in the same area. However, an association was observed between localities with treated waters containing more than 0.1 milligrams per litre of aluminum. These findings, while consistent with earlier findings reported in England and Wales, do not prove that there is a cause-effect relationship.[67] Further study will be needed to determine what role, if any, aluminum has in this disease.

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motor co-ordination as well as poor long-term memory in elderly persons with high amounts of aluminum in their blood.

High levels of aluminum can also result in kidney impairment, anemia, softening of the bones, glucose intolerance, lung diseases, and cardiac arrest. Animal experiments indicate that aluminum accumulates in liver, lungs, kidney, brain and skeletal tissues. However, except in extraordinary circumstances, most people are highly unlikely to be exposed to aluminum in quantities sufficient to cause any of these difficulties.

Very few studies have attempted to relate occupational aluminum exposure to harmful effects on the nervous system. One exception is a study from the University of Toronto that found a relationship between intentional exposure to aluminum dust and memory loss in northern Ontario hard-rock miners.[64, 68]

Kidney dialysis patients may develop a condition called dialysis encephalopathy, which seems to be related to aluminum uptake from the dialysis procedure. Symptoms of this syndrome may include chronic psychiatric or neurological problems including speech disorders, seizures, motor problems, memory loss, and psychotic reactions.[69, 62]

Mineral Fibres

Asbestos is the commercial name for a family of naturally occurring mineral fibres that are found throughout the world. Asbestos fibres are strong, durable and noncombustible. Because of these properties, asbestos is widely used for building materials such as insulation, fireproofing, cement, and floor and ceiling tiles.

Manufactured mineral fibres have been developed for a number of reasons. One of these reasons was the recognition that asbestos could cause disease and that alternatives were necessary. These fibres are used in the same way as asbestos. Some, like fibreglass, are well known in the marketplace.[70]

Mineral fibres have been linked for many years to certain kinds of lung and respiratory ailments. Historically, the main culprit has been asbestos.

Asbestos

Asbestos is a potential health danger to people who are exposed to high concentrations over a prolonged period of time. Such exposure has been connected to asbestosis, lung cancer and mesothelioma, a rare cancer of the chest or abdomen lining. There is also a possibility that this type of prolonged exposure is linked to cancer of the stomach and intestines.[26, 71] Therefore, asbestos mining and industries

Asbestos Exposure and Cigarette Smoking

Studies from around the world have shown that the health hazards of occupational exposure to asbestos, particularly to the respiratory system, are dramatically increased by cigarette smoking.

For example, cigarette smoking increases the incidence of asbestosis, a disease of asbestos workers that is characterized by scarring of the lungs. The occurrence of asbestosis in nonsmoking asbestos workers is approximately 0.8 percent, while in cigarette-smoking asbestos workers, it is 1.8 percent.[34] This means that asbestos workers who smoke have twice the risk of developing asbestosis that non-smoking workers have.

Asbestos exposure by itself increases the incidence of lung cancer about five to seven times, while cigarette smoking alone increases it about 15 to 20 times. But when smoking and asbestos exposure occur together, the risk of lung cancer jumps to 50 to 100 times that of the non-smoker who is not exposed to asbestos.[34] A 1979 American study showed that workers who were exposed to asbestos and smoked had 53 times the risk of lung cancer as had people who were not exposed to either carcinogen.[34] This kind of effect is known as synergism (see Chapter Two).

related to the manufacture, installation, or use of products containing asbestos involve activities that could be potentially hazardous to workers. This is particularly true where adequate protective measures are not taken in the workplaces.

In the past, people working with fibrous materials followed poor safety practices. Lung damage can be avoided by using adequate protective gear, including special masks.

The health effects of asbestos are believed to be a result of its fibrous nature and the unique ability of some of these fibres to be trapped in, and damaging to the lungs. When the fibres are caught like this, some researchers believe they upset the body's own defence systems, causing the systems to work against themselves.[34]

Under normal conditions asbestos fibres are not released from construction materials, so they present no danger to the public. There has been some concern, though, about possible exposure to fibres released from damaged, crumbly, asbestos-containing material, mainly in public buildings where it was sprayed onto surfaces for fire protection. One of the reasons for concern may have been the fact that sprayed asbestos was eliminated in the 1970s; the public may have thought that this suggested a significant risk to people occupying buildings treated with this material. However, the spraying was stopped to safeguard the workers applying the asbestos, not because it was a public health hazard.

The air inside buildings – including those where sprayed materials containing asbestos have been damaged – usually has about the same asbestos concentrations as in the air outside. Therefore, it is not a significant risk, although it is of concern to many workers in such buildings. Most other asbestos-containing products used in homes are rigid and do not release fibres in normal use. Renovation and maintenance may release fibres, so care should be taken under these circumstances.[71]

Authorities are aware of the health risks associated with the uncontrolled use of asbestos, and have placed increasingly stringent regulations and restrictions on manufacturing and using products containing asbestos. In fact, some countries have severely regulated them. In the United States, for instance, the Environmental Protection Agency is attempting to ban and phase out asbestos over a 10-year period.

Canada and many other nations have adopted strict regulations to control exposure to asbestos, thereby reducing health risks. Consumer products that can readily release asbestos fibres have been banned under the Hazardous Products Act. Regulations to restrict the sale of loose asbestos to industrial users have been developed under this Act. Also, regulations on asbestos released into the environment have been made under the Canadian Environmental Protection Act.

As a naturally occurring mineral fibre, asbestos is widely distributed in the earth's crust. As well, it may find its way into water supplies because of its extensive industrial use. Because of this, some people are concerned that asbestos might be dangerous if it were present in sufficient quantities in drinking water. However, there has been no consistent, convincing evidence that ingested asbestos is at all hazardous, as it is when inhaled. Therefore, the *Guidelines for Canadian Drinking Water Quality* do not limit it.

Manufactured Mineral Fibres

Manufactured mineral fibres are also fibrous, although they have a different shape than asbestos. People worried about the safety of some of these substitute materials believe they may cause health problems similar to those of asbestos. Even though cause-effect relationships are extraordinarily difficult to pin down, the International Agency for Research on Cancer (IARC) has classified several of the manufactured mineral fibres as "possibly carcinogenic to humans."[70]

The difficulty in proving or disproving the safety of these kinds of products lies in the fact that illnesses that may result from exposure do not develop immediately. In fact, they often take 20 years or more to develop.

Common air pollutants include sulphur dioxide, carbon monoxide, total suspended particulates, nitrogen dioxide and ground-level ozone. Some progress i being made in reducing the concentration of these contaminants in the air.

Transported Air Pollutants and Respiratory Health: The Tillsonburg/Portage La Prairie Study

Do moderately elevated levels of transported air pollutants affect respiratory health? This was the question asked by researchers from Health and Welfare Canada when they conducted a study from 1983 to 1984 that compared respiratory health and lung function of school children in two locations with differing levels of transported pollutants in the outdoor air. They chose Tillsonburg, a town in southern Ontario with elevated concentrations of air pollutants, and Portage La Prairie, a Manitoba town in a low-pollution area.

In Tillsonburg, 735 children between the ages of seven and 12 participated in the study, while in Portage La Prairie, 895 children in the same age group took part. Three measures of respiratory health were obtained for each child. One was a questionnaire to assess each child for chronic respiratory problems; it was completed by a parent. Another measure was obtained by telephone interviews with a care-giver every two weeks for 18 weeks to keep track of each child's current respiratory health — that is, whether the child suffered from coughs, wheezing, chest colds, and such during that period. The third measure was taken from standard tests of lung function that were performed on all the children.[73]

Researchers monitored outdoor air in both locations during the study in order to define community differences in air pollution and to track pollutant levels to see if there might be immediate health effects from periods of higher pollutant concentrations. The study took into account external factors such as parental smoking, socio-economic status, and type of heating in the home.

Researchers noted a small but significant difference in lung function and capacity. The Tillsonburg children had a lower score on the lung tests than their counterparts in Portage La Prairie. As well, Tillsonburg children had more respiratory symptoms. Persistent chest colds occurred more in Tillsonburg, as did stuffy noses and coughs with phlegm. Tillsonburg children also reported more allergies to substances breathed in, such as smoke, dust, pollen, mould or anima hair.[73]

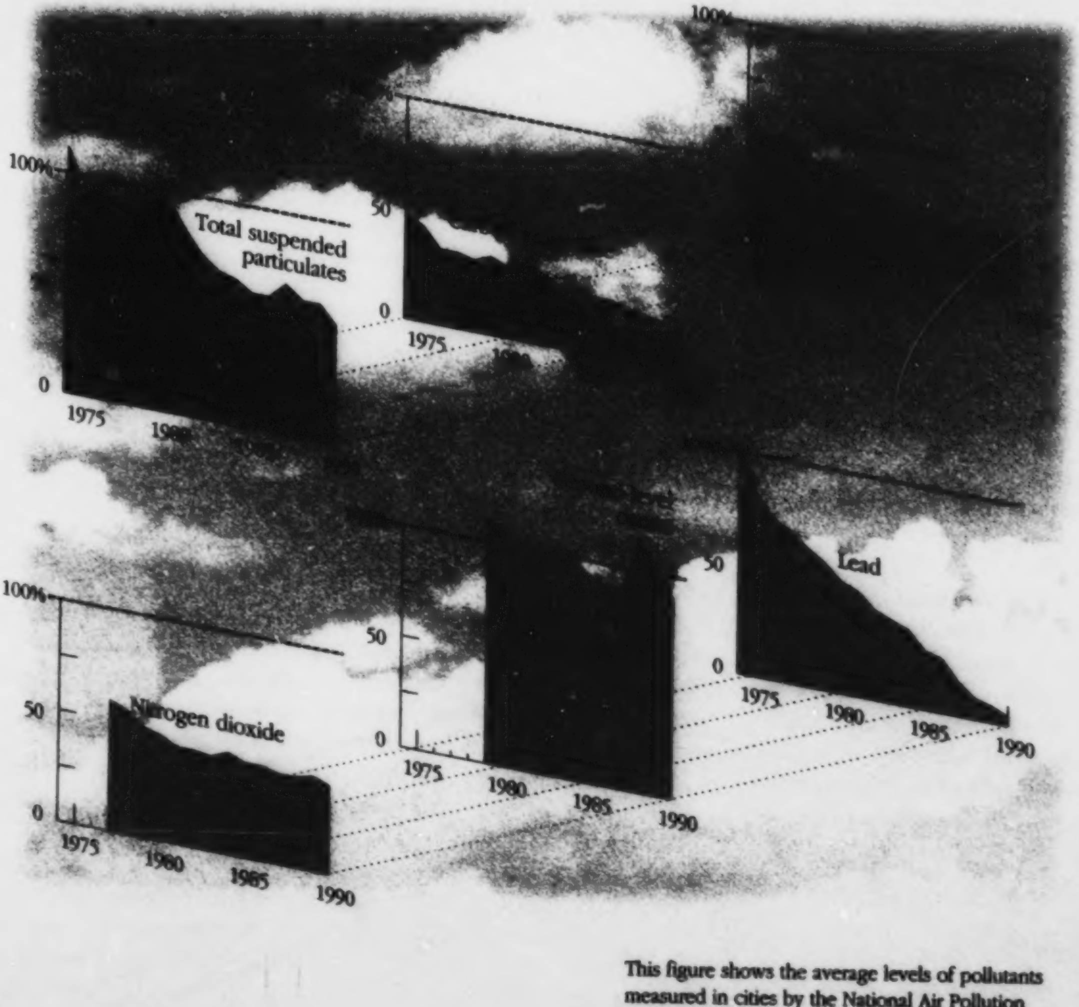
Because of this, manufactured mineral fibres and several other naturally occurring fibrous materials are included on the Priority Substances List under the Canadian Environmental Protection Act. This means that scientists are assessing the toxicity of these materials to human health and the environment. If necessary, these substances will be regulated.

Air Pollutants

Common pollutants in outdoor air were the first pollutants to be identified and monitored. They are among the most prevalent pollutants in the environment, although they are not necessarily the most toxic. They include sulphur dioxide, carbon monoxide, total suspended particulates (TSPs), nitrogen dioxide, and ground-level ozone.

In 1969, a committee made up of both federal and provincial authorities agreed to create the National Air Pollution Surveillance (NAPS) network and established the Federal/Provincial Advisory Committee on Air Quality. This network, which has been expanded extensively since its establishment, was set up to keep track of levels of common air pollutants across the country.[25]

Figure 14
Trends in Canadian Air Quality[72]



This figure shows the average levels of pollutants measured in cities by the National Air Pollution Surveillance network. The pollutants are shown as a percentage of the maximum acceptable levels for the National Ambiant Air Quality Objectives. Since there is no objective for lead, the percentage decline is based on the 1974 average.

Air-quality objectives for common pollutants developed for Canada have taken into account both the concentration of a particular pollutant and the duration of exposure to it. This is a three-tiered system of objectives meant to establish tolerable, acceptable, and desirable levels of pollutants.

The trends of average levels of air pollutants in cities are indexed to the maximum acceptable level of the National Ambient Air Quality Objectives shown in figure 14.[72] Note that since there is no objective for lead, the percentage decline is based on the 1974 average. The maximum acceptable level has been set to ensure adequate protection against adverse effects on humans, soil, water, vegetation, materials, animals and visibility. It is quite clear from these trends that some progress is being made in reducing the concentration of many of these contaminants in the air.[25]

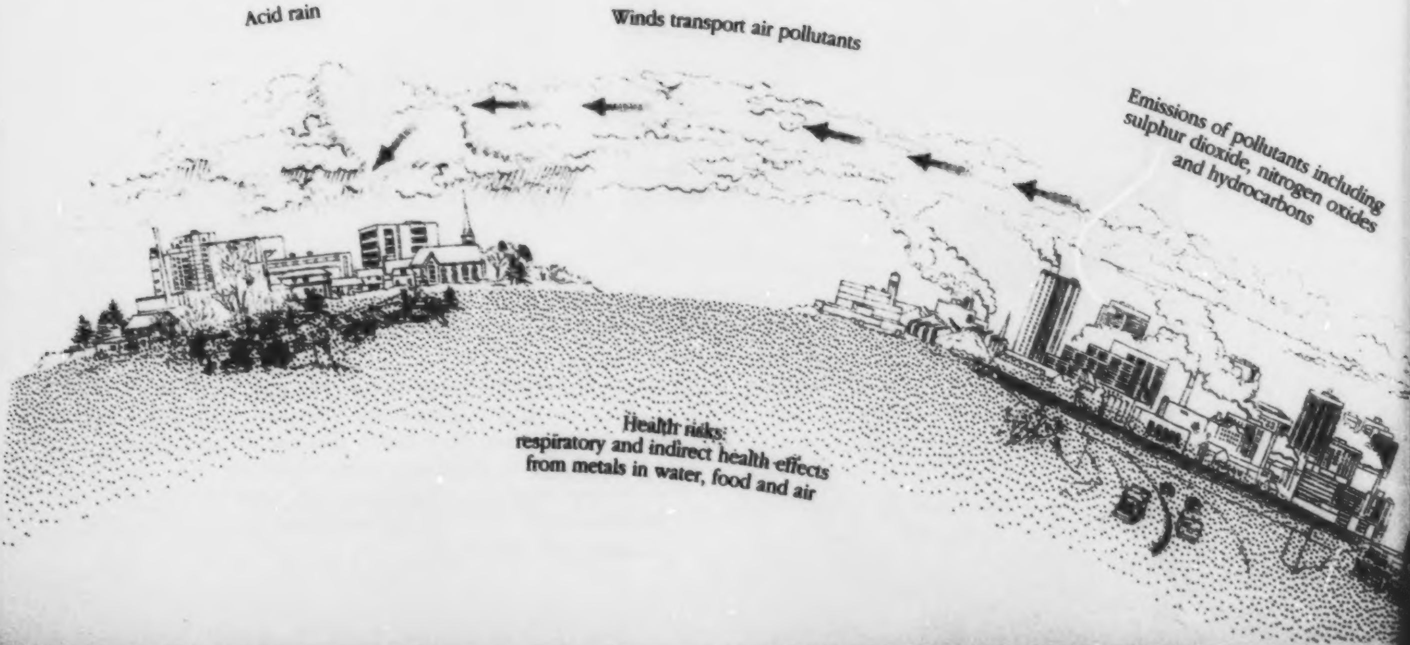
Although this trend is comforting, it is important to point out that yearly averages alone are not adequate to indicate the potential for health effects. The episodes of high emissions and the exposure to them at the time they occur are also important factors from a health point of view.

Acid Rain

Acid rain is largely caused by the contaminants sulphur dioxide, nitric oxide, and total suspended particulates (TSPs). The term "acid rain," while commonly used, is not exactly accurate, since precipitation in the form of rain or snow is not the only means of transporting and depositing this acidic material. It can travel as a vapour, although much of it occurs as fine particles or in gaseous form. Since acid rain carries chemicals that are considered air pollutants, it is both an air and a water pollutant.

There is still some controversy about the magnitude of human health effects from acid rain, but studies have shown that exposure to it may result in both acute and chronic respiratory problems.

Figure 15
Exposure to Hazards of Acid Rain


Acid rain
Winds transport air pollutants
Emissions of pollutants including sulphur dioxide, nitrogen oxides and hydrocarbons
Health risks:
respiratory and indirect health effects from metals in water, food and air

The Long-Range Transport of Airborne Pollutants

Acid deposition, commonly known as acid rain, has been recognized as an environmental problem for some time, although the extent of its possible environmental effects is still debated.

The impact on human health is even less clear. Studies have shown that high levels of some of the transported pollutants do relate to a decrease in lung function in children,[6, 74] and researchers suspect that repeated incidents of this type may lead to chronic lung problems. Also, the acidification of lakes promotes the taking up of metals from bedrock into the water. This has the potential to cause problems in the ecosystem and to human health.

In June 1980, the federal government approved a program on the Long-Range Transport of Airborne Pollutants (LRTAP). Principal departments involved include Health and Welfare Canada, Environment Canada, Fisheries and Oceans, and Forestry Canada.

The environmental objective of the LRTAP program is to reduce wet sulphate deposition – a major component of acid rain – to a level that would protect moderately sensitive areas. This objective requires a 50-percent reduction in Canadian emissions of sulphur dioxide (at 1980 levels) east of the Saskatchewan-Manitoba border to be achieved by 1994. Similar reductions are necessary in the eastern United States.[74]

Both Canada and the United States have decreased sulphur dioxide emissions significantly. Some lakes and rivers in Ontario, Nova Scotia and Newfoundland are recovering, although areas that are still receiving deposits of too much acid continue to deteriorate.[74, 25]

The two long-term objectives of the LRTAP program's health sector are:

- to assess the risk to human health posed by airborne pollution that crosses the borders, and
- to monitor the influence on human health of programs to reduce pollution.

Health and Welfare Canada has conducted many research initiatives to this end, and there are many more under way. For instance, the studies on lung function previously mentioned were done under the auspices of this program.[74]

As well, researchers are developing ways to improve estimates of human exposure to acidic air pollution and are investigating the ways in which pollutants become toxic to the human body. Several long-term research projects are being done. These include:

- a joint U.S.-Canada investigation in 24 North American communities to assess the health impact of long-term exposures to airborne acidic pollution in children, and
- further investigations of the relationship between episodes of air pollution and hospital admissions or visits to the emergency department or both.

Sulphur Dioxide

In addition to considerable background levels of sulphur dioxide from natural sources such as volcanoes, 98 percent of manufactured sulphur dioxide originates from industrial processes and fuel combustion. High levels of sulphur dioxide in the air have been linked to respiratory and lung problems, including reductions in lung function. As well, short-term acute exposures have been related to an increased number of hospital admissions and deaths.

It is difficult to assign blame to a particular pollutant like sulphur dioxide in health studies involving episodes of high pollution because there are always many pollutants present in the air at the same time. Controlled experiments, though, have shown that sulphur dioxide affects lung function. Emissions and measured levels of sulphur dioxide have declined significantly since the early 1970s.[25]

Carbon Monoxide

The major manufactured source of carbon monoxide in Canada is from fuel combustion in vehicles and also from stationary engines. Other important sources of carbon monoxide emissions are industrial, such as burning fuel to generate electricity or heat.[75]

As mentioned previously, the greatest health danger from carbon monoxide stems from its ability to interfere with the exchange of oxygen and carbon dioxide that takes place in the lungs.[39] Hemoglobin, protein matter in blood, carries oxygen to body tissues. However, carbon monoxide, which also bonds with hemoglobin in blood, can replace oxygen in the hemoglobin. This effectively cuts off the vital supply of oxygen to the body. Heavy smokers, as well as people with heart problems, anemia, or blood circulation difficulties may be at greater risk than other people when they are exposed to relatively high levels of carbon monoxide.

Outdoors, carbon monoxide seldom reaches potentially dangerous levels. In fact, it has shown a general decline over the past 15 years (figure 15). Levels recorded now by the National Air Pollution Surveillance (NAPS) network generally show the gas hovering around the "desirable" level according to the federal government's air quality objectives; this is the lowest level of concentration in the three-tiered system. However, pollution episodes occasionally put the concentration of carbon monoxide over the acceptable levels for short periods of time.[25]

Total Suspended Particulates

Total suspended particulates (TSPs) refer to minute bits of matter carried along in the air. While there have always been particles in the air in the form of dust, pollen, ash and smoke, in more recent times industrial activity has added to the measured levels of suspended particulate matter. These particles may take many forms, solid or liquid (aerosol). Emissions of fine particles from sulphur dioxide and nitrogen oxides may be acidic, affecting lung function in a somewhat different manner than chemically neutral particles. As well, these acidic particulates affect the environment as a whole.[74]

Chemical fires release toxic substances into the air. These can be hazardous to the health of people living nearby.

The size of these particles may vary a great deal. This is significant because the size of the particles influences the potential for causing health problems, since size is directly related to the ability of the particles to get into the lungs and stay there.

Particulates deposited in the respiratory system are thought to aggravate already existing lung and heart disease. As well, TSPs may inhibit the respiratory system's ability to clear itself. Some researchers claim that other body defence mechanisms are also affected.

TSPs are thought to be one of the critical contaminants during most episodes of high pollution. Children, the elderly, asthmatics, smokers, people suffering from heart disease and those with the flu or bronchitis may be at particular risk during these times.[8, 76] Trends in average levels of TSPs in Canada show a general decline since 1974.[25]

Nitrogen Oxides

Emissions of nitrogen oxides in Canada increased substantially from 1970 to 1985. Nitrogen oxides include a number of gases that are composed of oxygen and nitrogen. The two most important of these oxides in polluted air are nitric oxide and nitrogen dioxide. Combustion of fuel for transportation, home, and industrial use accounts for approximately 94 percent of the emissions of nitrogen oxides from manufactured sources in Canada.[25]

These oxides affect lung function and cause irritation of the respiratory system, particularly in people who already suffer from asthma or bronchitis. As well, some studies have indicated that high levels of these gases may affect the body's ability to defend itself against bacterial and viral infection. Children seem particularly sensitive to the detrimental effects of chronic exposure to nitrogen oxides.[6]

Ground-level Ozone

In unpolluted air, ozone at ground level is a natural gas occurring in concentrations that do not affect health. However, in polluted air, ozone can increase to unhealthy levels. The accumulation of ground-level ozone is a separate problem, however, from that of stratospheric ozone which is being depleted in the upper reaches of our atmosphere. Stratospheric ozone is discussed in Chapter Four.

In air that is not polluted, nitric oxide helps to control the amount of ozone at ground level by picking up an atom of oxygen from the ozone and creating more oxygen and nitrogen dioxide. Thus, under normal circumstances, ozone in the air we breathe remains in low concentration and is not a problem.

Ozone at ground level accumulates in greater concentrations than normal, however, when a certain type of pollution affects the way nitric oxide behaves. When the air is polluted by organic gases and vapours called volatile organic compounds (VOCs), nitric oxide combines with them instead of with ozone. This complex series of chemical reactions uses energy from the sun's ultraviolet rays and creates a buildup of ozone at ground level, creating a potential pollution problem.

High concentrations of ground-level ozone often occur in or near heavily populated areas, where vehicles and industry emit the abundance of nitrogen oxides and VOCs necessary to produce and trap ground-level ozone.

Interestingly enough, ozone exposure seems to affect all adults to about the same extent, including people such as smokers and asthmatics who are more sensitive to other pollutants.[25]

Many researchers feel that ozone is the common air pollutant that is most detrimental to human health. Because urban areas may have intermittent but high concentrations of ground-level ozone, air-quality objectives were developed, based on a one-hour exposure (82 parts per billion). Some areas in Canada exceeded this level at certain times last year.[25]

As well as being a pollution problem in high concentrations, ground-level ozone is considered one of the "greenhouse" gases that are warming the planet as a whole.

The Difference Between Ground-level and Stratospheric Ozone

By now, most people are familiar with the term "ozone," and realize that it is a major environmental problem. In fact, there are two problems associated with ozone. The first of these is the depletion of ozone in the upper reaches of the atmosphere, known as the "stratosphere." The second is the accumulation of ozone at ground level, in the air we breathe.

Each of these two problems is thought to result in very different health effects. Ozone in the stratosphere protects the earth from the sun's harmful ultraviolet rays, so that its depletion means that more ultraviolet light will reach us. Scientists predict that an increase in ultraviolet rays will cause an increase in the incidence of skin cancer, eye disorders (particularly cataracts), and a possible increase in diseases of the immune system.

Ozone at ground level acts as an oxidizing agent, affecting the respiratory system. High levels of ozone may interrupt or damage the respiratory system, and reduce lung function. Infants and small children are especially at risk, since ozone seems to particularly affect growing lungs and may lead to chronic obstructive lung disease.[6, 77] A buildup of ozone at ground level may result in breaking down the immune system if exposure is prolonged.[25]

Chapter Four
Pesticides and Other Organic Compounds

Pesticides and synthetic carbon compounds are among the most widespread chemicals to appear in the world this century. These organic chemicals, used extensively at different times by agriculture and industry, have aroused growing public concern.

Pesticides

Pesticides are chemicals and biological compounds used to control pests such as insects, rodents, weeds, bacteria, viruses and fungi. Most households contain pesticides of one sort or another. For instance, people regularly use mothballs to protect wool fabrics, or chemicals to kill bugs around the house. It is important to remember that such compounds have been created to kill an organism and deserve a certain respect while they are being handled.

The development of synthetic organic chemicals as pesticides began before the Second World War and their use has steadily grown since that time. In Western society, pesticides are used mostly in agriculture. Agriculture Canada has registered for use more than 500 active chemical ingredients for pesticides. However, only about 100 of these are used regularly. As well as traditional agricultural methods (such as rotating crops, tilling agricultural wastes and using the pests' natural enemies), chemicals are used to control pests.

Farmers and environmentalists, as well as federal and provincial officials, are beginning to use "integrated pest management," an attempt to put together the best of both approaches to farm management. They have become aware of increasing public concern about how pesticides affect the environment, as well as the pests' own ability to develop a resistance to the chemicals.[26]

Crops are sprayed with pesticides to prevent damage from natural sources. Careful application can help minimize exposure to the general population.

Sources of Exposure

The public is exposed to pesticides mainly from residues in food and, to a smaller extent, in drinking water. Pesticide residues in food are strictly regulated by Health and Welfare Canada under the Food and

Drugs Act and Regulations. The *Guidelines for Canadian Drinking Water Quality* now set acceptable levels for many pesticide residues in drinking water because of the extensive agricultural use of pesticides and the finding of low concentrations in untreated water.

Pesticides may enter water supplies directly or indirectly.

- Direct entry into drinking water may happen when pesticides are accidentally spilled, siphoned into wells when they are being mixed, disposed of incorrectly, and sprayed over water for mosquitoes and blackflies. Pesticides may also drift off the target during aerial spraying, and contaminate water run-off from fields; this may happen when pesticides are applied at hydro, highway, and railroad borders.
- Water may be contaminated indirectly if pesticides applied to crops filter through the soil and into ground water. This may occur as well at hazardous waste sites. Effluents or waste from pesticide manufacturing and home disposal may also end up in the water supply.

Pesticide residues may result from the use of pesticides on the farm, or from treating crops after harvest or processing them to prevent spoilage or insect infestation. The Food and Drug Regulations set out the maximum amount of pesticide residues that can be present on crops or in food products such as meat, flour, fruits and vegetables. Both Canadian and imported foods are tested regularly to ensure that these products meet the standards set in the Regulations.

People exposed to pesticides as a result of their work, or as a result of the casual use of pesticides include farmers, greenhouse workers, builders using pressure-treated wood, and people who spray homes for insects, or lawns for weed control. Home gardeners and people who use insect repellents or sprays are also exposed. Most pesticide exposure comes from contact with the skin.

Herbicides

In Canada, herbicides are the pesticides most studied for their effect on people. An important reason for these studies is because many pesticides are used regularly on Canadian farms, and because of the controversy surrounding a particular herbicide sometimes known as Agent Orange.

Agent Orange is a defoliant composed of two phenoxy herbicides, 2,4,5-T and 2,4-D. The U.S. military sprayed it from the air to clear undergrowth in Southeast Asia during the Vietnam war. This action gained notoriety because Vietnamese and American people were sprayed in the process, resulting in claims of illness.

The phenoxy herbicide 2,4-D is still used widely on Canadian farms, whereas 2,4,5-T is no longer registered in Canada. Reports of effects on health from exposure to phenoxy herbicides are limited to situations where people have been exposed to levels higher than those commonly found on farms.[78]

One problem with 2,4,5-T was that a specific type of dioxin, TCDD, was present in the commercial product. TCDD (or, more correctly, 2,3,7,8-TCDD) is the most toxic form of dioxin and has been known to cause chloracne, a skin disorder, in workers manufacturing the herbicide. Some workers also complained of general debility and weakness, loss of appetite, and nausea. However, these effects resulted from chronic exposure to high concentrations.

In the past, 2,4-D preparations were found to be contaminated by dioxins, excluding the most toxic TCDD. Since this contamination was discovered, production has been modified so that 2,4-D should not contain more than minor traces of dioxins – less than 10 parts per billion. On the basis of human and animal studies, scientists believe that the proper use of currently registered 2,4-D products should not pose a health risk to people applying the products or to the general population.[79] However, the toxicity of pure 2,4-D continues to be studied.

Insecticides

The three major classes of chemical insecticides are the organochlorines, the organophosphates and the carbamates.

Organochlorines

The organochlorines are chlorine-containing insecticides that have diverse chemical structures ranging from the fairly simple to the very complex. This group of compounds includes such familiar names as DDT, chlordane, toxaphene and lindane, among many others.

Because of their particular structure, the organochlorines do not break down easily and therefore remain in the environment for a long time. As a result they have a tendency to accumulate in the food chain, possibly resulting in unhealthy concentrations in the fatty tissues of higher animals and humans.

Because of these characteristics, there has been some concern about the possible long-term health and environmental impact when complex chemicals are used. Consequently, some organochlorine pesticides such as DDT and toxaphene are no longer registered for use in Canada. They are included in the revised drinking water guidelines, however, because they may still be detected in surface and ground-water supplies in certain areas. Since the mid-1970s organochlorine compounds have been largely replaced in Canada with other less persistent chemicals.

The organochlorines act on pests by affecting the nervous system. In high doses they disrupt nervous system impulses. Acute human exposure may produce excitability,

Breast-feeding infants promotes sound nutrition and helps protect them against disease.

Farmers' Health

Because farmers are exposed to a variety of potential health hazards – including solvents, fuels, farm machinery, waste gases, and particularly pesticides and herbicides – Health and Welfare Canada, in collaboration with Statistics Canada, has undertaken a study to investigate the relationships between various farming practices and specific causes of death.

The first part of this study has now been completed. The study showed that fewer farmers died from non-Hodgkin's lymphoma – a type of cancer that affects the lymphatic system – than did members of the general population. However, there was a relationship between the incidence of the disease in farmers and the number of acres they sprayed with herbicides, as well as the amount of fuel and gas used on the farm.

The findings are based on data from the 1971 Census of Agriculture, the 1971 Central Farm Register, the 1971 Census of Population, and the Canadian Mortality Data Base. Earlier studies done in the United States, Australia and New Zealand demonstrated a possible increased risk of non-Hodgkin's lymphoma in farmers.[80]

Exposure of Dene Indians to Toxaphene

In 1986, the Dene Indians in the Northwest Territories requested assistance from the Department of Fisheries and Oceans to investigate a problem they were encountering with local fish. Over the previous few years, people reported catching fish with a variety of abnormalities. In particular, some loche – also known as burbot or methy – had shrunken and discoloured livers.

During their investigations, scientists from the Department of Fisheries and Oceans discovered that loche liver contained residues of the pesticide toxaphene, at unusually high levels. This pesticide is not used locally and is believed to originate in the southern United States. Although these residues were not linked to liver deformities, the scientists advised the Dene to ask for assistance in determining whether these high levels of toxaphene had any affect on health.

The Dene requested an investigation by Health and Welfare Canada, which began in 1988. In 1989, officials from Health and Welfare Canada, Fisheries and Oceans, and Indian and Northern Affairs Canada discussed the results of their testing. They concluded that the main source of toxaphene exposure for the Dene was from eating loche liver. Health and Welfare Canada established a level of tolerable daily intake (TDI) for toxaphene for seasonal use. The maximum intake of toxaphene by a member of the Dene from eating loche liver was considered to be well below the TDI level. The officials concluded, therefore, that loche and loche liver were safe to eat in the amounts consumed at that time.[81]

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headache, disorientation, convulsions, coma and death. Organochlorines must be carefully used to ensure that they do not have adverse effects on humans similar to those documented for sea birds and laboratory animals, where these complex chemicals were found to interrupt normal breeding cycles and cause birth defects.

Insecticides that have been developed to replace the organochlorines include the organophosphates and the carbamates.

Organophosphates

The organophosphates are the most widely-used group of insecticides in the world today. They include parathion, malathion, chlorpyrifos, diazinon and many others. These agents break down relatively readily by enzyme action in living organisms or by other processes in the environment. Organophosphates are generally less persistent and less likely than organochlorines to accumulate in animal and human tissues. They are, however, more water-soluble, and in some cases more likely to reach water supplies.

Organophosphates are generally considered to be acutely toxic to humans and animals at relatively low doses, although malathion and a number of commonly used compounds only show effects at quite high doses. The differences in toxicity are due to differences in how the body metabolizes, or breaks down, the various compounds. For this reason, malathion does not cause the same difficulties that might be caused by other compounds of this type.

Organophosphates interfere with nerve impulses, thus disrupting the body's nervous system. Overexposure could lead to a range of possible effects including sweating, vomiting, diarrhea, coughing, loss of co-ordination, weakness, paralysis, mental confusion, convulsions, coma, and, in extreme circumstances, death. A very large exposure would be necessary to cause such extreme effects.

Because organophosphates are less likely to bioaccumulate, people have preferred to use them as insecticides. However, some do not break down in use as quickly as scientists originally thought, so they may persist for some time in the environment. Farmers find these insecticides useful because there are so many of them to choose from to control different pests.

Carbamates

Carbamate insecticides also tend not to bioaccumulate and, like the organophosphates, are quite water soluble and may reach water supplies. Some but not all of the carbamates are less toxic than the organophosphates, although if someone suffers acute poisoning the effects are similar. On the other hand, the most acutely toxic pesticide registered for use in Canada, aldicarb, is a carbamate. Other examples of carbamates are propoxur and carbaryl.

Others

Many other types of pesticides are used in Canada. Examples are: warfarin, a blood anticoagulant used to combat rodents; wood preservatives such as creosote; and fungicides used on a variety of fruits and vegetables. Pyrethrins are also used widely in certain products for home use. Like all pesticides, these other chemicals have the potential to cause harm to human health if a person is exposed to sufficient quantities.

Regulation

In Canada, pesticides are registered by Agriculture Canada under the Pest Control Products Act. Health and Welfare Canada is responsible for regulating pesticide residues in food under the Food and Drugs Act and Regulations. Maximum residue limits established by the Department apply to foods that are either produced domestically or imported. Health and Welfare Canada also administers the *Guidelines for Canadian Drinking Water Quality* and serves as an adviser to Agriculture Canada on the health risks to workers or bystanders exposed to pesticides. Environment Canada and the Department of Fisheries and Oceans also provide advice to Agriculture Canada.

Alachlor

In February 1985, the Minister of Agriculture cancelled the registration of the herbicide alachlor, used to control weeds in corn and soybeans. The Minister of Agriculture may cancel the registration of a pesticide if its use will lead to damage of the environment or human health.

In the case of alachlor, the Minister acted on the advice of Health and Welfare Canada. Scientists at the Department stated that tests showed alachlor to be an animal carcinogen and that it should be considered a potential human carcinogen. They also expressed concern about the exposure of people applying the pesticide, as well as exposure of the public through water contamination. Metolachlor, another commercial herbicide with the same function as alachlor, did not demonstrate a comparable health risk and could be used as a safer substitute.

The Canadian manufacturer of alachlor requested a review of the Minister's decision, as provided for under the Pest Control Products Act. In November 1985, the Alachlor Review Board was formed to examine the evidence leading to the Minister's decision and to hear testimonies from interested parties. In October 1987, the Board submitted a report to the Minister of Agriculture, recommending that the Minister restore the registration of alachlor. It concluded that, while both alachlor and metolachlor were animal carcinogens, removing either product from the market could have adverse economic effects for farmers. The Review Board also believed that, while alachlor should be considered a potential human carcinogen for regulatory purposes, it did not pose a threat to the public or to people applying it.[82]

However, after seeking advice from Health and Welfare Canada, the Minister of Agriculture decided against restoring the registration of alachlor. Occupational exposure to alachlor was associated with excessive cancer risk — even when protective measures were taken — and a less hazardous alternative was available. Alachlor is no longer on the market in Canada.

Chlorinated Hydrocarbons

This is a large and varied group of chemical compounds, most of which result from industrial activities. Each chlorinated organic compound contains carbon, hydrogen, chlorine, and sometimes oxygen atoms. Some of these chemicals are routinely mentioned in the media. They include polychlorinated biphenyls (PCBs), dioxins and furans.

In Canada, nationwide surveys of chlorinated hydrocarbon residues in human fat tissue were carried out in 1969, 1972, 1976 and 1985.[83] The studies (see figure 16), showed a downward trend in residue levels in each of the five regions of Canada, although 1985 levels for Manitoba and Saskatchewan were not available.

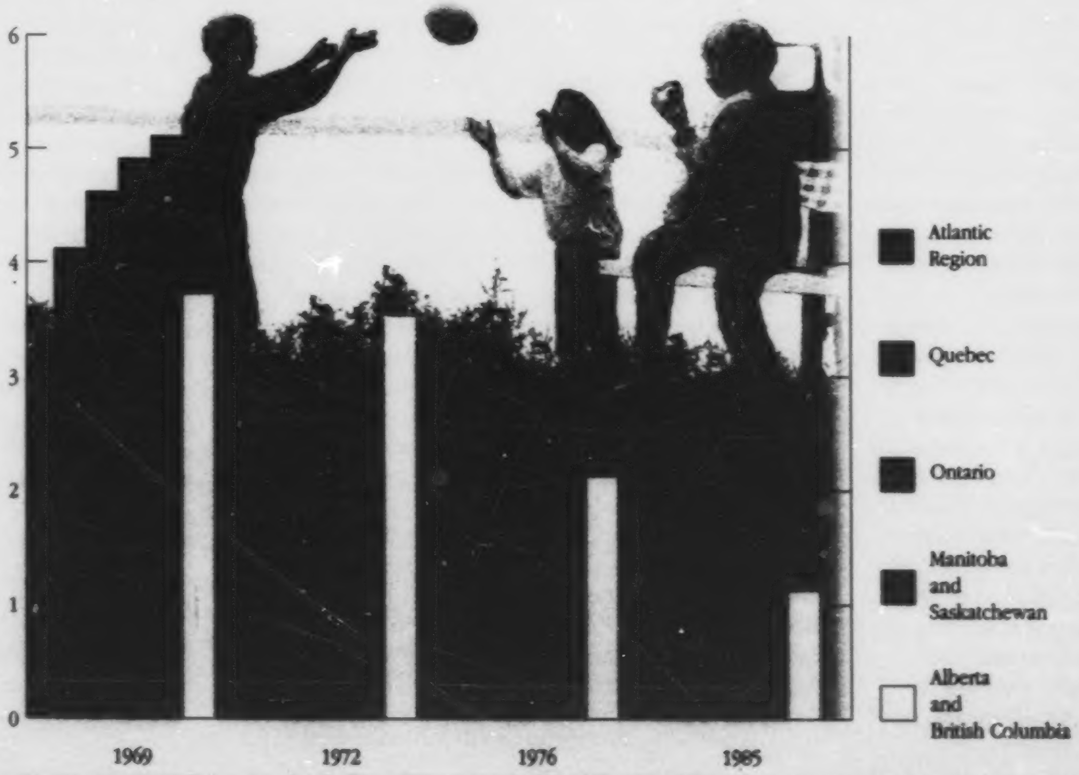
In many cases, restrictions on the use of certain industrial chemicals have led to these lower levels. For example, after the use of DDT was gradually restricted from 1969 to 1978 and completely banned in all foods in 1978, a continuous decrease in the levels of DDT found in human tissue was observed. PCBs followed a similar pattern after their use was restricted in 1977; surveys done before 1977 showed no decrease in residue levels of PCBs in the Canadian population, but by 1985 the Canadian levels had been halved.[83]

PCBs

PCBs are heavy, nonflammable, stable oils that have a high boiling point and conduct electricity very poorly. Because of these properties and their low toxicity during short-term exposures, PCBs were used extensively in electrical heat transfer and hydraulic equipment. They were also used for other purposes, such as de-inking fluid for newsprint and as a component of carbonless copy paper, some paints, waxes, and various industrial oils.

The careless disposal of electrical equipment is generally accepted as the major route for PCBs into the environment, where they are now found everywhere. They are transported through water and soil, and occasionally through the air when waste materials containing PCBs are burned.

Figure 16
Chlorinated Hydrocarbon Residues in the Fat Tissue of Canadians [83]
(in parts per million)



PCBs are readily soluble in fat tissue and can therefore spread throughout the body. These chemicals do not decompose easily and persist for a long time in the environment. There may be a significant increase in the concentration of these PCBs as they are passed up the food chain to humans. Although the manufacture of PCBs was banned in 1977 in North America, trace quantities are still found everywhere: in soil, plants, marine organisms, fish and other animals, and humans.

Estimates have been made of the average intake of PCBs over a lifetime for people in different groups.[85] Anglers consume by far the greatest amount of PCBs – 0.2 micrograms per kilogram of body weight each day. However, this is well within the guideline of one microgram per kilogram of body weight each day. Although breast-fed children do get a slightly higher dose of PCBs over a lifetime than bottle-fed children, there are many other health benefits that outweigh this factor, so breast-feeding is recommended.

The diet of people who live in the Arctic is different from that of other Canadians. This diet is thought to be especially suited to survival in these particularly harsh conditions.

The Storage and Transport of PCBs

PCBs are no longer being produced. Nonetheless, the task of storing and transporting wastes that are contaminated with PCBs poses potential environmental hazards if it is not undertaken carefully. The federal government has set up stringent regulations to protect Canadians and the environment from risks during PCB transport or storage.

The transport of wastes containing PCBs is carefully regulated under the Transportation of Dangerous Goods Act, administered by Transport Canada. All equipment containing PCBs must be drained of the PCB mixture before being transported, and all openings in the equipment must be capped or sealed. The equipment must then be placed in a leak-proof container or in a drip pan with absorbent material. Each shipment must be inspected at regular intervals during transport.[84]

The Act also covers the possibility of accidents causing major releases of PCBs. Prior to transport, all carriers of PCBs must have an emergency response plan. Each shipment of contaminated wastes must also be accompanied by a document describing the wastes so that information is readily available in an emergency.[84]

The Canadian Environmental Protection Act (CEPA) regulates the storage of wastes containing PCBs. The regulations were added to the Act following the fire at a PCB storage site in Saint-Basile-le-Grand, Quebec, in August 1988. Except for Prince Edward Island, the Yukon and the Northwest Territories, all the provinces have compatible regulations. Under CEPA, all storage sites must now meet strict criteria to protect human health and the environment. These include:

- *Identification and Reporting:* All quantities of PCB-containing wastes must be identified and reported to the appropriate authorities.
- *Site Requirements:* Storage sites must be designed so that any accidental spills or leaks can be contained and prevented from being released into the environment.
- *Fire Protection and Emergencies:* Fire protection must be provided at each storage site. In addition, fire and emergency control plans, as well as inventory information, must be provided to the local fire department in the vicinity of each site.
- *Maintenance and Inspection:* Personnel handling wastes containing PCBs must be adequately trained. Inspections must be regularly completed, and necessary repairs to the facility must be made promptly.
- *Books and Records:* A complete inventory of on-site wastes and incoming and outgoing wastes must be kept, including records of inspections and actions taken.[84]

All federal sites are inspected regularly to ensure that they comply with the Act's requirements for safe storage. In a similar way, provinces and territories inspect sites under their jurisdictions.

The Broughton Island Study

There is growing concern that the levels of PCBs consumed by Inuit in the North may be unacceptably high. Their higher intake is the result of their traditional Arctic diet, which consists of large quantities of fish and sea mammal blubber, in which the PCBs accumulate.

Concern about the PCB content in Arctic foods arose after it was discovered that abandoned Distant Early Warning (DEW) line sites were contaminated with PCBs. There was some suspicion that the DEW line sites might be the source of PCB pollution in the Arctic; however, the clean-up showed that these sites only had local effects. It is now generally accepted that the PCB contamination in the Arctic is part of global contamination. Contaminants are brought north from industrialized southern regions by ocean currents and air movement, and then accumulate in the food chain.

In 1985, Health and Welfare Canada conducted a study of the PCB levels in arctic food. The study was conducted at Broughton Island, a community just north of the Arctic Circle in the Northwest Territories. This site was chosen because it had a high per capita consumption of local foods. The study included an assessment of diet, and analyses for PCB content of different foods, of blood, and of breast milk.

The results showed that about one-fifth of the participants consumed more than the tolerable daily PCB intake of one microgram per kilogram of body weight. Blood PCBs exceeded the guidelines established by Health and Welfare Canada in 63 percent of children, in 39 percent of women of childbearing age, in 6 percent of adult males, and in 30 percent of women 45 years and older. PCB levels in breast milk were within the range found in southern Canadian samples.[86]

The researchers concluded that the food chain in the Eastern Arctic is indeed contaminated with PCBs, and the dietary habits of many Inuit increase their chances of consuming high amounts. Because the analysis of PCBs in food, blood, and milk is extremely difficult, it is not easy to measure accurately how much people consume. As well, the consequences of long-term low-level exposure for adults are not known. While experiments have shown that high levels of PCBs cause cancer in animals, there is no convincing evidence that they cause cancer in humans. In view of the benefits of the traditional diet, the researchers suggested that it would be incorrect to propose a change in diet until more is known about exact levels of PCBs and their effects.[86] Certainly the benefits of breast-feeding are well known and this practice is encouraged.

To expand upon the findings of the pilot study, and to examine more fully the nutritional benefits of Inuit traditional foods, seven additional dietary assessments were conducted in Broughton Island during the period from July 1987 through August 1988. These follow-up studies yielded the same conclusions: the researchers again recommended that the known benefits of consuming traditional Arctic foods outweighed the possible risks. They also suggested that the shift from Arctic foods to market foods could have adverse effects on health – for example, deficiencies of certain essential nutrients, and increased risk of obesity, cardiovascular disease, and cancer.[87]

The movement to stop producing PCBs began in the late 1960s when an outbreak of acute PCB poisoning occurred in Yusho, Japan. Victims exhibited a number of adverse effects as a result of eating food cooked in rice oils that were accidentally highly contaminated with PCBs. The most common manifestation of the exposure was chloracne. The contaminated rice oil contained extraordinarily high concentrations of furans, chemical compounds similar to dioxins, which are now believed to be the primary cause of the harmful health effects.

Short-term, high-level exposure of the type just described is extremely unlikely to occur in the general population. In fact, even longer-term, low-level exposures of health significance are very rare, and usually limited to people who are exposed at work. In order to help measure the exposure of

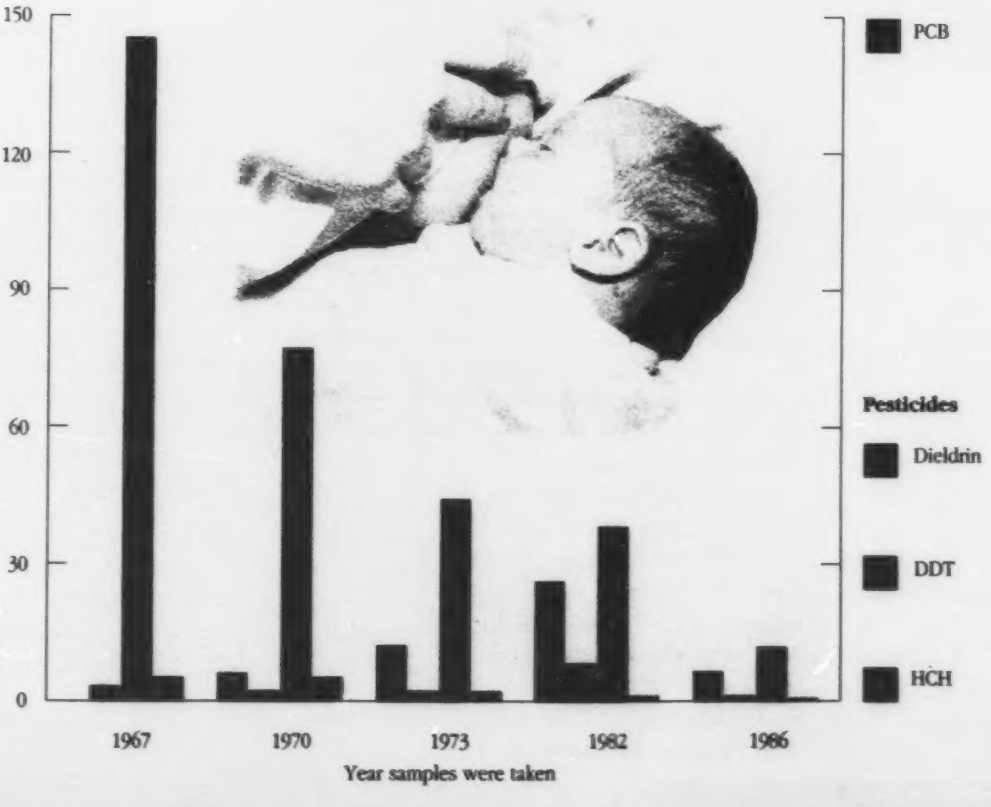
Canadians to a variety of pollutants such as PCBs, new procedures are being considered (see "A New Test for Contaminants").

Some studies have indicated a relationship between PCB levels in the blood and the amount of fish eaten by people in the Great Lakes basin. One study found that pregnant women who regularly ate fish from Lake Michigan had more infections, anemia, and retention of body fluid. As well, birth weights were lower than normal, and babies were born prematurely more often. Some of the infants had minor reflex and motor difficulties.[88, 89]

A New Test for Contaminants

Scientists at Health and Welfare Canada are estimating the exposure of women to pollutants by analyzing the body fluid that bathes the human egg, or ovum. The liquid, or follicular fluid, is obtained from women participating in *in vitro* fertilization clinics. A small volume of fluid is collected and the contaminants are extracted and measured by very sensitive analytical methods. Several substances detected at low concentrations include PCBs, hexachlorobenzene (HCB), and DDE (a DDT breakdown product). Preliminary results show that there are significant differences across the country in the pattern and levels of these contaminants. Analysis of ovarian follicular fluid, along with other biological monitoring procedures, may help to show trends in the levels of contaminants among Canadians and will help authorities decide how to reduce contamination in the future.

Figure 17
Pesticides and PCBs in Breast Milk (Whole Milk) in Canadians[90]
(in parts per billion)

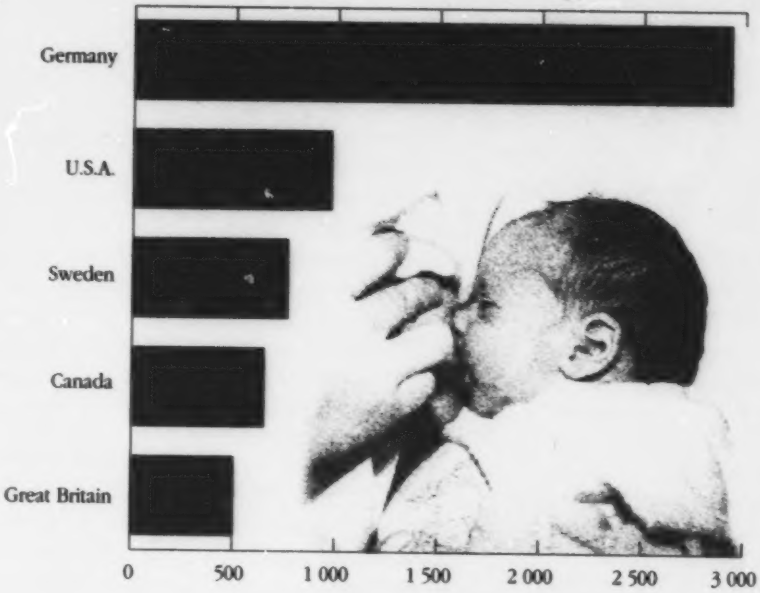


These studies are important, but their results should be interpreted cautiously. The studies were limited in size, somewhat inconsistent in what they found, and did not take into account other factors, including other chemicals. Also, PCB levels in blood from the umbilical cord did not relate to the amount of fish the mothers ate.

For the past two decades, Health and Welfare Canada has been monitoring the presence of chlorinated hydrocarbons – particularly PCBs – in the breast milk of Canadian women. This procedure developed out of concern for developing infants, who are particularly vulnerable to chemical contaminants.

The results of these monitoring programs have been encouraging, showing a demonstrated decrease in pesticides such as DDT and its derivatives, as well as heptachlor epoxide and dieldrin. PCB levels in whole breast milk have decreased dramatically in recent years (see figure 17), and PCB levels in breast milk fat compare favourably with those reported in other Western nations (figure 18).[90]

Figure 18
Comparison of PCB Residues in Breast Milk (Milk Fat) in Several Countries[90]
(in parts per billion)



Dioxins and Furans

Two families of related compounds that have been a source of public concern are polychlorinated dibenzodioxins (dioxins) and polychlorinated dibenzofurans (furans).

While they can originate from natural sources such as forest fires, most dioxins and furans in the environment are the result of industrial activity, such as by-products formed when various chemical compounds containing chlorine are burned. They also occur as impurities in a number of industrial chemicals.

Dioxins and furans can enter the environment from a wide range of sources, including commercial chemicals such as wood preservatives, pulp and paper mills that use chlorine bleaching, and combustion sources such as incinerators, burning wood, and motor vehicles. The most significant potential source of furans is PCBs, in which furans are usually present as trace contaminants. PCBs are subject to strict handling and storage requirements, but accidental fires or spills may release them into the environment.

Once they are released, dioxins and furans can stay in the environment for many years without breaking down. As a result, they are everywhere in the environment, although at very low levels. Techniques for measuring levels of these substances have become increasingly more sensitive, allowing these chemicals, present in such small quantities, to be measured. As these techniques have improved, trace levels have been found in animals and humans everywhere.

Much of the concern about dioxins and furans stems from the results of animal toxicity tests. Animals exposed to 2,3,7,8-tetrachlorodibenzodioxin (TCDD), the most toxic of the dioxins and furans, experience a number of adverse health effects, including weight loss, skin disorders, impaired liver function, impaired reproduction including birth defects, and cancer. Some other members of these chemical families have similar effects but are less potent than TCDD.

Dioxins and Furans in Fish

Pulp and paper mills have been in the news in recent years because the effluent (waste water) from mill processes contains many potentially hazardous chemicals. About 300 different chemical compounds including dioxins and furans have been identified in effluent from pulp and paper mills.[91] Dioxins and furans are groups of substances that have been classified as "toxic" to health and the environment under the Canadian Environmental Protection Act. They are chemical by-products that are released during the process of chlorine bleaching used in some pulp and paper mills. One of the major problems with dioxins and furans is their tendency to accumulate in aquatic organisms, where they may present a health risk to people who eat fish or shellfish.

The National Dioxin Sampling Program was announced by the Minister of Fisheries and Oceans in January 1988, in response to growing public concern over the discharge of dioxins and furans by pulp and paper mills using the chlorine bleaching process. This comprehensive national sampling and monitoring program was put into place to test fish and shellfish in the vicinity of 47 pulp mills using the chlorine bleaching process. To date, sampling and analyses have been conducted in British Columbia, Alberta, Saskatchewan, Quebec, Ontario and the Maritimes.

A National Dioxin Sampling Program was developed to test fish and shellfish in the vicinity of 47 pulp mills.

In November 1988, the Department of Fisheries and Oceans implemented commercial shellfish harvesting closures in the immediate vicinity of three coastal pulp mills in British Columbia. This action was taken to protect the integrity of the fishery and to protect consumers from exposure to products taken from the contaminated areas.[92]

The decision to close these fisheries was based on advice from Health and Welfare Canada that frequent consumption could result in harm to health from elevated levels of dioxins and furans found in these species. This advice was based on a health assessment process that takes into account the number of samples, the full range of dioxin and furan compounds found, the toxicity of each compound, and the amount of and parts of fish that could be consumed by an individual.

From November 1989 to August 1991, a number of other commercial as well as recreational fisheries were examined across Canada and, where warranted, there were closures and, in some cases, consumption advisories were issued.[93, 94] The Ontario data were being analyzed in 1991 to provide the basis for health recommendations. The sampling results for the Maritimes indicated that the levels of dioxins and furans detected were too low to warrant closures or to issue health advisories.

It is important to point out that the majority of samples analyzed across Canada did not contain dioxins or furans at levels that would pose a health threat.

The Department of Fisheries and Oceans and Environment Canada are working together to revise the pulp and paper regulations under the Fisheries Act. As well, new regulations are being developed under the Canadian Environmental Protection Act. The revised regulations will require mills using chlorine bleaching to implement process changes that will prevent the formation of dioxins and furans in effluent. Some pulp mills have already taken steps by substituting chemicals and changing equipment to reduce the contamination from dioxins and furans.[95]

Dioxins and furans can enter the environment from a wide variety of sources, such as pulp and paper mills. Many pulp mills have changed their bleaching process to reduce the production of dioxins and furans.

It is difficult to assess exactly the human health effects of dioxins and furans. Since these compounds are contaminants of various chemical products, people are exposed to them at the same time as they are exposed to other chemicals that are often present in higher concentrations. It does appear, however, that effects on humans are much more limited than effects on animals.

In studies of people exposed to dioxins and furans in the workplace or through accidents, the health effect most consistently observed is chloracne. Some of these studies have also reported other skin problems, as well as adverse effects on the liver, immune system, senses and behaviour. Most of these effects are temporary, although chloracne has persisted for many years in some cases. It is important to note that the people in these studies often had extreme exposures. The levels of dioxins and furans in their fat were many times higher than those found in the general public.

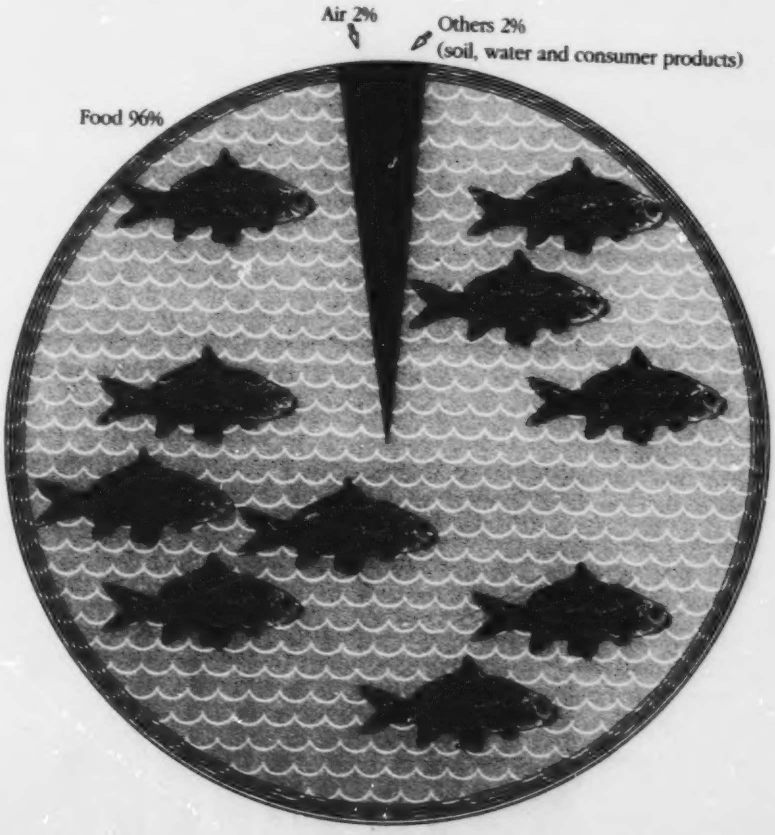
The main way in which Canadians are exposed to dioxins and furans is through contaminated food (see figure 19), such as fish, meats, poultry, eggs, milk and dairy products. Air, soil, water and consumer products are minimal contributors to exposure.[96]

Controls

The federal government has implemented a wide range of controls to minimize exposure to dioxins, furans and PCBs. The sale and use of pesticides containing TCDD has not been permitted for some time, and the content of other dioxins in pesticides is strictly limited. Federal stores of PCBs are being destroyed in mobile high-temperature incinerators.

These efforts to control releases have had a positive impact. Levels of dioxins and furans in fish-eating

Figure 19
Intake of Dioxins and Furans by Canadians[96]



While few people are exposed to dioxins and furans, those who are exposed receive most of these substances from food rather than from air or other sources. Most food is, in fact, free of dioxins and furans.

birds in the Great Lakes have declined. As well, surveys reveal that levels of PCBs and dioxins in human tissue in Canada and other industrialized countries have stabilized or declined.

The federal government remains committed to minimizing exposure to dioxins and furans. Regulations have been proposed that would prohibit pulp mills from discharging measurable levels of the most toxic dioxins and furans. Also, limits on the release from mills of other chemicals containing organic chlorine are being considered. Controls on incinerator emissions of dioxins and furans have also been recommended.

Hydrocarbons

Hydrocarbons are common air pollutants, although they are not measured like other air pollutants because there are so many of them. It is almost impossible for scientists to interpret the measurements since hydrocarbons are so numerous and their levels can vary radically.[25]

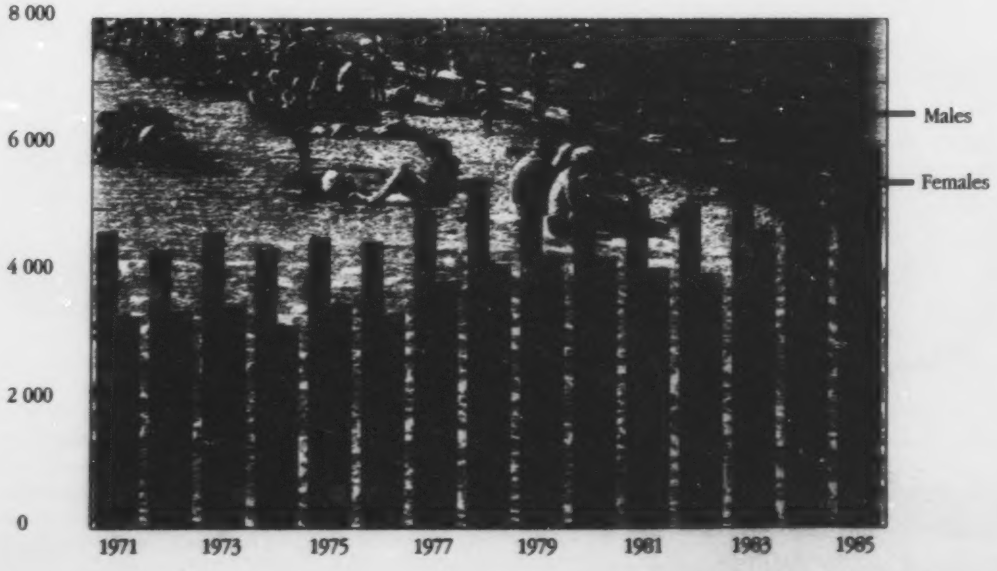
Individual compounds may be measured because of a known health effect. For example, benzene, a volatile organic compound, might be measured because it is carcinogenic. Hydrocarbons are often considered and measured as secondary air pollutants. In Canada, emissions of hydrocarbons increased approximately 15 percent between 1970 and 1985. This was primarily because of uncontrolled emissions from industrial processes and from such activities as burning wood waste from forestry operations.[25]

The category of secondary air pollutants is a catch-all for a large group of varied contaminants. This group has little in common in terms of structure, human health effects or environmental effects. Because of this, these contaminants may be studied in a number of different ways. Researchers could focus, for instance, on a single contaminant or perhaps a single group of contaminants. Alternatively, a particular activity could be studied, such as copper smelting, or perhaps a certain geographical area with local pollution problems.

CFCs and Halons

One group of pollutants that has received a lot of attention in the last few years is the chlorofluorocarbons (CFCs) – molecules containing carbon, chlorine and fluorine – and a related group, the halons, containing carbon and halogens (fluorine, bromine and chlorine).

Figure 20
Incidence of Non-Melanoma Skin Cancers for Canadians of All Ages[99]



CFCs and halons do not occur naturally but are manufactured for industrial and home uses. For example, the cooling coils in refrigerators or air conditioners are filled with CFCs. They are also used as foaming agents and cleaning solvents and, until recently, were used as propellants in aerosol cans. Halons are used primarily in fire extinguishers.

The Destruction of Stratospheric Ozone

CFCs and halons, along with methane and nitrous oxide, are implicated in the destruction of ozone in the stratosphere (part of the upper atmosphere). This is a serious problem because without ozone, a gas that acts as a screen for the sun's harmful ultraviolet rays, more of these rays can reach us.

CFCs are very stable in the lower atmosphere but they drift up to the stratosphere over a period of years. Here they can decompose and release their chlorine, which destroys ozone molecules. One molecule of chlorine can destroy up to one million molecules of ozone before leaving the atmosphere.[97]

Ironically, the increases in ultraviolet radiation resulting from ozone depletion may enhance the accumulation of ground-level ozone which, in high concentrations, causes respiratory problems.

Skin cancer is the most common type of cancer in Canada. There are an estimated 25 000 to 40 000 new cases of skin cancer in Canada each year. Most cases of skin cancer can be surgically treated, but they represent a significant cost to our health-care systems.

Up to two percent of all skin cancer cases are of a special group called melanoma. This kind of skin cancer is fatal in 70 percent of cases. It is the fastest growing type of cancer reported in Canada, after lung cancer in women.

The relationship between ultraviolet radiation and non-melanoma (usually non-fatal) skin cancers is well documented. However, the role of ultraviolet radiation in promoting malignant melanoma skin cancer, which is often fatal, is still not clear. Some scientists think that the depletion of the stratospheric ozone layer will increase the amount of ultraviolet radiation striking the earth, thereby increasing the rate at which skin cancers are formed. Some sources have speculated that a one-percent decrease of the ozone layer will increase ultraviolet radiation by two percent.[98] It has been suggested that a two-percent increase in ultraviolet radiation will result in a three- to six-percent increase in non-melanoma skin cancer rates. Figure 20 reveals the recent increasing trend in non-melanoma skin cancers. This increase may not only result from stratospheric ozone depletion but also from lifestyle changes – that is, more outdoor leisure time. However, it underlines the link between exposure to ultraviolet radiation and skin cancers.[98]

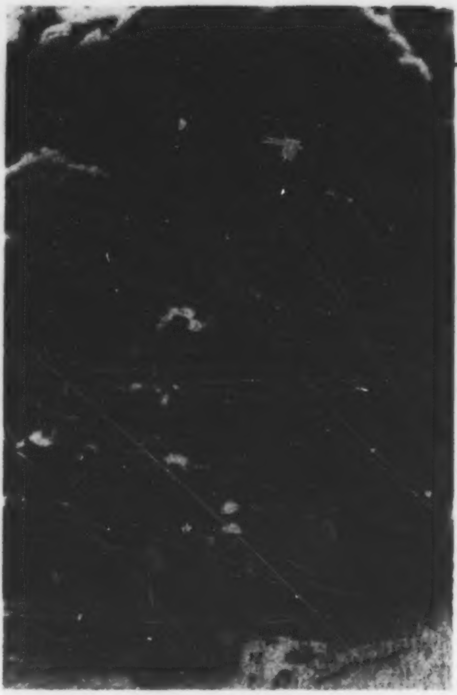
Control

Government policy-makers provincially, nationally and internationally are working towards controlling the release of CFCs into the atmosphere. For instance, the use of CFCs as propellants for aerosol cans was restricted in North America in the 1970s, causing a decrease in their production throughout the world. (The Montreal Protocol in 1987 went further by getting industrialized nations to significantly reduce their use of CFCs – see Chapter Nine, "The Montreal Protocol and Ozone Depletion.") Canada's consumption of CFCs is down 45 percent from its peak in 1987. However, since the 1970s, CFCs have been used in other ways, so the downward trend in production has now reversed. Consequently, international agencies such as the United Nations Environment Program are moving to reduce the use of CFCs around the world.

PAHs

Polycyclic aromatic hydrocarbons (PAHs) are also considered to be secondary air pollutants. PAHs are components of petroleum, and may be released through evaporation, or burning fuel of various sorts for industry or transportation. They are also produced by cooking, for example charbroiling meat. PAHs are usually associated with fine bits of matter (particulate matter), which may give them more "access" to the human body through the lungs.

Burning any material containing carbon and oxygen may release complex mixtures of PAHs; therefore monitoring and studying the effects of particular PAHs in isolation is not only a problem, but also artificial. Researchers have identified at least 300 different PAHs in cigarette smoke alone.[25]



The Hagersville tire fire burned for 17 days and was the worst tire fire in Canadian history. Every effort was made to minimize the exposure of nearby residents to contaminants.

Environmental Emergencies: A Tire Fire

A fire broke out at the Tyre King Recycling depot in Hagersville, Ontario, the morning of February 12, 1990. This was the worst tire fire in Canadian history, with almost 14 million tires burned in 17 days. As with most environmental emergencies, this situation was a provincial responsibility. Several Ontario ministries, including the Ministry of the Environment, formed a team to cope with this crisis. While the team's main task was to fight the fire to protect the health and safety of local residents, it was also concerned about the contamination of the environment – that is, both air and ground-water pollution by polycyclic aromatic hydrocarbons (PAHs) and dioxins.

Health and Welfare Canada's emergency response capability was immediately mobilized in order to be able to respond to possible requests of the Ontario government, and to protect the health of people under federal jurisdiction, including residents of Indian reserves.

The Department began collecting information on possible health effects of contaminants emitted as the tires burned. It examined the regulatory limits around the world for these contaminants in air, soil, water, and food. Information such as this is essential to assessing risks to health.

By the fourth day of the fire, the Department began discussions with the Ontario Ministry of the Environment, the Ontario Ministry of Agriculture and Food, and Agriculture Canada about the safety of food. They set up a program to sample and analyze food commodities that could potentially be affected by the smoke from the fire. Sampling continued until there was no further danger that foodstuffs such as vegetables, meat and milk would be polluted.

Health and Welfare Canada, as health adviser to other federal departments, was asked to evaluate data and advise Environment Canada on the risk posed by airborne contaminants being monitored by that department. Data were collected on contaminants in the smoke plume as well as at sites downwind and adjacent to the fire where there was no direct impact by smoke. PAHs were the most worrisome airborne contaminants. However, only direct inhalation of the smoke posed a health hazard.

The fire was located three miles from the Six Nations Indian Reserve. The Department, in keeping with its responsibility to protect the health of Reserve residents, assisted the provincial authorities in accommodating the needs of the Indian people. Approximately 3 500 Reserve residents were evacuated until the smoke dissipated. Environmental Health Officers of the Department ensured that food and water on the Reserve were inspected for possible contamination.

To protect the health and safety of residents of the New Credit and Six Nations reserves, water was tested for dioxins, furans and a wide variety of other contaminants that might come from the fire. Both government and private laboratories were used to test the samples on an emergency basis. No significant contamination was found of the drinking water from these reserves and the water was judged fit to drink.

By the end of February, the fire was extinguished, and the clean-up operations had begun. Although the crisis was over, the sampling and analysis of food and water continued until it was certain that there would be no health risks. Although the environmental damage was extensive, human health risks were avoided by a carefully co-ordinated response.

PAHs at high levels can cause cancer in humans. Percival Potts first observed this in 1775. He noted that young chimney sweeps had a tendency to develop scrotal cancer and assumed that their illness resulted from exposure to the soot in the chimneys where they worked. Although Potts could only identify the cause as soot, later study has concluded that PAHs are the component of soot that caused the cancer. PAHs have also been implicated in genetic change and problems in development, and are linked to a large number of skin disorders, including cancer.

Benzo(a)pyrene is a common PAH that is also considered to be highly carcinogenic. Elevated levels of this chemical have been associated with residential wood burning, aluminum smelting and coke ovens. It is believed that PAHs are transported long distances in the atmosphere.[26, 25, 75]

Coke Oven Emissions

Coke is a residue from the heating (destructive distillation) of coal and is used primarily as a fuel in blast furnaces producing steel. A coke battery usually consists of 10 to 100 ovens arranged in parallel rows. A coke plant may have one to 12 batteries of ovens and a number of auxiliary structures where coke and coal are transported, processed and stored. A number of air pollutants, particularly PAHs, are created during the coking process.

The coke ovens at Sysco (Sydney Steel Corp.) in Sydney, Nova Scotia, operated for many years prior to closing in 1983 because of a coke surplus. In 1985, Environment Canada asked Health and Welfare Canada to assess the potential health impact of restarting the coke ovens. It was recommended that the coke ovens not be reopened unless suitable pollution-control devices were installed.[101]

In assessing risks, Health and Welfare Canada took into consideration that:

- emissions from coke ovens increase the risk of cancer for workers;
- emissions of PAHs in Sydney prior to the shutdown were about double those in Hamilton, Ontario, where coking operations are also carried out. It is important to note that there were only two coke-oven batteries operating at Sysco, compared with 47 batteries operating in Hamilton;
- based on mortality statistics, there was a statistically significant increase in deaths from cancer in men and women in Sydney, downwind from the plant, as compared with men and women in Sydney Mines, upwind;
- reopening the Sysco plant without additional emission controls could increase sickness and death of workers at the coke plant and possibly of residents in Sydney.[101]

In addition to atmospheric emissions from the ovens, untreated liquid effluent from them was released into Muggah Creek. The sediments in the creek were heavily contaminated with PAHs and the area was referred to as the "tar ponds" because of the black, thick nature of the sediment. In 1980 and 1981, a survey by the federal Department of Fisheries and Oceans found that lobsters in Sydney Harbour had increased levels of PAHs. The source of the PAHs was identified as the tar ponds, and subsequently commercial fishing of lobsters in South Arm (near the tar ponds) was banned for an indefinite period. A recent study undertaken by Health and Welfare Canada sought to determine if fishermen, who had fished in the area of Sydney Harbour, had a higher than normal incidence of cancer. The concern was expressed that these fishermen had consumed lobsters from their own catch for many years and therefore had been exposed to PAHs for a long time. The findings indicated that no statistically significant increase in cancer was detected among fishermen in general or more specifically in lobster fishermen from Cape Breton or from Sydney Harbour.[102]

While a number of lifestyle factors such as smoking and diet may influence findings in this risk assessment, it is clear that a public and occupational health problem was associated with these coke ovens. The coke ovens were closed in 1988 and replaced by a less polluting electric arc furnace. The tar ponds are being cleaned up.

Volatile organic chemicals are organic gases and vapours present in the air. Sources include solvents used in spraying paint and in coatings.

Volatile Organic Compounds
Volatile Organic Compounds (VOCs) form another group of chemicals causing concern as both indoor and outdoor air pollutants. VOCs are organic gases and vapours present in the air. There are many sources of VOCs, largely centred around the burning or use of fuels. They also are associated with solvents, coatings, and dry cleaning operations. Thousands of VOCs may be present in the air at any one time, and may be transported over long distances.

Many VOCs have been identified as human carcinogens. Benzene, for instance, is a well-known VOC that causes cancer. It is a component of gasoline used to run vehicles. Hexane at high levels has been implicated in nervous system disorders. For the most part, though, the sources and the health effects of VOCs are just now being identified.[39, 25] Researchers are studying a number of VOCs that are Priority Substances under the Canadian Environmental Protection Act to determine their toxicity to humans and the environment. Because VOCs are so diverse, the task of managing them is complex.

Chapter Five
Micro-organisms

Micro-organisms have always been with us and are everywhere. They exist in air, water, soil, food, and in and on our bodies. These organisms, which cannot be seen by the naked eye, include bacteria, fungi, protozoa, and viruses. While most of these microscopic "bugs" are harmless and many are beneficial, some do cause discomfort or illness in humans, ranging from allergies to infections. On rare occasions they can cause death.

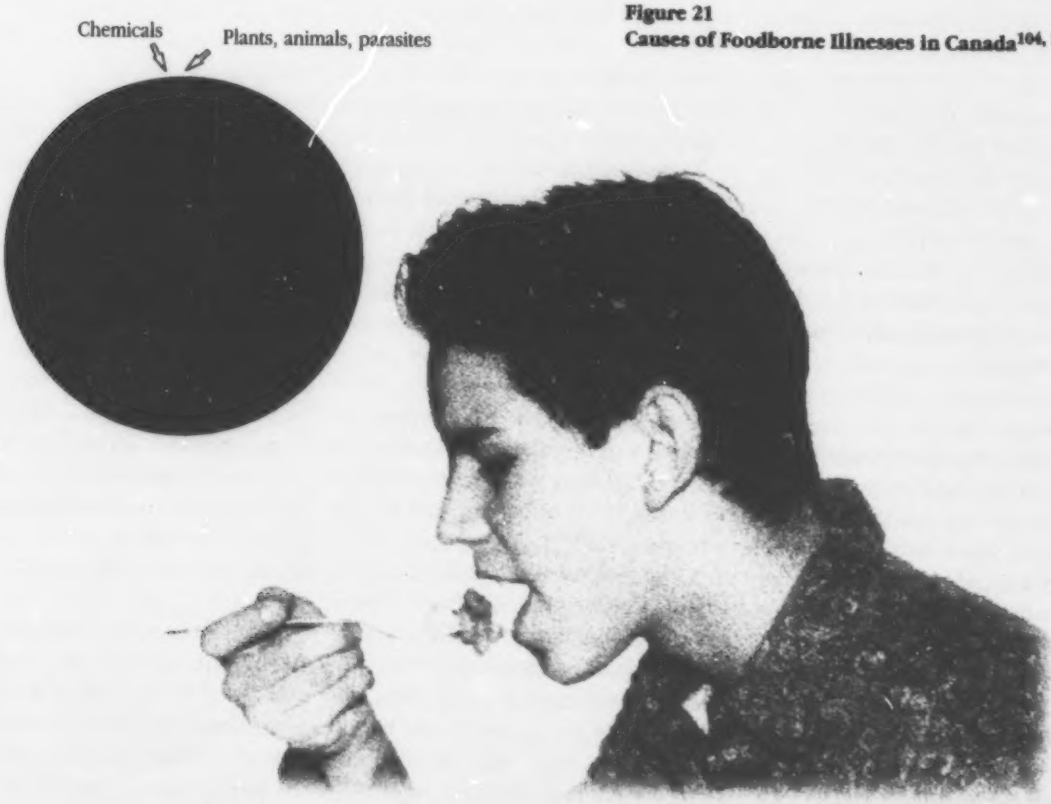
Contact with Micro-organisms

We come into contact with harmful micro-organisms mainly from eating, drinking, breathing indoor air, and using water for recreation.

Micro-organisms in Food

Food poisoning is caused by micro-organisms. Every year thousands of Canadians are reported to have been affected in this way,[13] although the numbers may be much higher because the symptoms of food poisoning are so similar to those of stomach flu that many cases go unreported (see figure 21).[51]

Figure 21
Causes of Foodborne Illnesses in Canada[104, 105]



Out of a total of 77 343 reported illnesses from 1975 to 1986 inclusive, 42 858 were from unknown causes, 32 958 were caused by micro-organisms, 1 033 by chemicals, and 494 by plants, animals or parasites.

Salmonella *is one of the most common causes of food poisoning. It occurs most often in raw milk, eggs and poultry.*

The effects of food poisoning caused by micro-organisms range widely, but the most common symptoms include stomach cramps, nausea, vomiting and diarrhea. Children, older people and the chronically ill may be especially affected, and particularly serious cases may lead to death.

Four types of micro-organisms contaminate food: bacteria, moulds, parasites, and algae that produce toxins in seafood.

Bacteria

Bacteria are common in the environment and in farm animals, so they are frequently found in raw food such as meats and poultry, eggs, and unpasteurized milk. Cooking normally kills these bacteria, but if meat and poultry are not well cooked, bacteria will persist and may result in illness.

The three most common types of bacteria associated with food poisoning are *Salmonella*, *Campylobacter*, and *E. coli* O157:H7 (the number denotes the particular strain of *E. coli* that is harmful). Other common bacteria that cause food poisoning are *Staphylococcus* and *Clostridium*.

Salmonella poisoning is perhaps the most well-known type of food poisoning; an estimated 600 000 cases of *Salmonella* poisoning occur in Canada each year, most of which are unreported. *Salmonella* most often occurs in raw milk, eggs, and poultry. The symptoms of exposure are cramps, vomiting, chills, fever and diarrhea. These symptoms occur between eight and 24 hours after eating, and last for a few days.[106, 51]

Campylobacter is found in infected domestic animals. The two species *Campylobacter jejeuni* and *Campylobacter coli* are the most common of the 10 or so species. The sources are generally raw milk, raw chicken, and meat. The symptoms are cramps, diarrhea, nausea, fever, vomiting, headache, and weakness. These symptoms occur three to five days after eating, and may last from three days to two weeks.

Of all the bacteria found in raw food, certain types of *E. coli* have the greatest potential to cause disease in humans. Illness caused by this strain is sometimes called "hamburger disease" because it is often associated with eating improperly cooked hamburgers. However, it can also occur in other kinds of meat and poultry. In ground meats bacteria can spread and multiply during and after the grinding. Exposure to this type of *E. coli* can lead to bloody or watery diarrhea and may cause kidney damage in children and the elderly. It is estimated that there are about 13 000 cases a year in Canada. In this country, seven deaths were attributed to these strains of *E. coli* in 1987.[51, 107]

Moulds

Moulds, a type of fungi, are capable of growing on many substances, depending on temperature and moisture.

Many moulds are useful to us. Cultivated varieties enhance the flavour of Camembert cheese, and give Blue and Roquefort cheese their marbled appearance and characteristic tang. Probably the most famous beneficial mould is *Penicillium*. The discovery of its ability to kill harmful bacteria led to the development of Penicillin, and the discovery of antibiotics began a whole new era in the treatment of disease.

However, many moulds are a health hazard. Some cause infections in various parts of the body including lungs, eyes and open wounds. Others produce substances known as mycotoxins. These can be dangerous if they are eaten or inhaled. Mycotoxins are persistent substances and may remain in a product even after the moulds that produced the mycotoxins are killed.

Aflatoxins are a group of mycotoxins of particular concern. They were discovered in 1960, when more than 100 000 turkeys in England died after eating imported peanut meal contaminated with the toxins.

Certain crops grown in warm, humid climates are susceptible to mould contamination that can produce aflatoxins. These crops include corn, tree nuts and peanuts. Aflatoxins are rarely found in Canadian field crops because of our cooler, drier climate.

Animal studies have revealed that aflatoxins are very poisonous at high concentrations, and that at lower levels eaten over a longer time, they may cause liver cancer. In addition, research in Southeast Asia and Africa has shown that liver cancer is significantly higher among certain groups of people who have a diet high in aflatoxins, although other factors such as local diseases may influence this incidence.[108]

Since moulds are a naturally occurring crop problem, it is not possible to eliminate all traces of aflatoxin from food. However, contamination can be minimized by carefully storing and handling crops after harvest, and by rigorously inspecting products before they are offered for sale.

Of all mycotoxins, aflatoxins are the most studied and regulated. Reduction of aflatoxin levels in food products is the shared responsibility of the grower, distributor and food processor. Health and Welfare Canada has an active program aimed at further reducing aflatoxin levels in foods such as peanut butter, peanuts, and other nut products sold in Canada.

Parasites

Parasites are organisms that live in or on another organism, and take the nutrients they need from that organism. Parasites infect various food animals, and may infest people who eat raw or undercooked foods, especially meat. When this happens, parasites can cause symptoms ranging from mild stomach cramps, nausea and vomiting to ulcers, anemia – a deficiency of red cells in the blood – and muscle pain.[109]

The most common parasites in fish are the cod worm, the herring worm, and the fish tapeworm. Cod worms are reddish in colour and can readily be seen in fillets. If these are consumed, they are usually passed through the body with no apparent symptoms. The Department of Fisheries and Oceans monitors raw cod fillets for these worms. The smaller, whitish herring worms are less easy to see. If these are ingested, they may burrow into the intestinal wall, causing pain, nausea and vomiting. In rare cases the worms have to be surgically removed. Both cod and herring worms may be present in a variety of commercially important marine fish.

Fish tapeworms are fairly common in fresh-water fish. While they are hazardous to humans, human infections are rare. In some cases, however, the worms have infected people and caused severe anemia.

Common parasites in meat are the beef tapeworm, the pork tapeworm, and the pork trichinosis nematode. Commercially available meat is closely monitored by Agriculture Canada, so parasites are rarely found in raw beef or pork from the supermarket. However, wild game in northern parts of Canada have many other parasites; blood tests on Native Canadians who live in these areas have shown that they are exposed to a number of these parasites from game animals.[110]

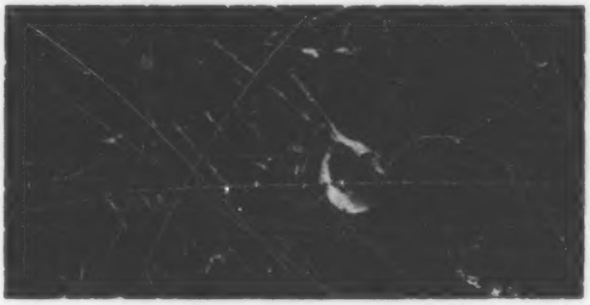
Parasites in fish and meat are killed by thorough cooking or by freezing. Human infections from foodborne parasites are rare, but when they do occur, they can present a serious threat to health.

Seafood Toxins

Poisoning from shellfish has become one of the most publicized types of food poisoning in Canada. However, the poisonous quality does not come from the shellfish itself, but from marine algae ingested by the shellfish. These algae produce toxins that accumulate in the shellfish. Some of these are not destroyed by heat; therefore both raw or cooked shellfish can be dangerous.

Paralytic Shellfish Poison (PSP) and the more recently discovered domoic acid toxin occur in molluscs (mussels, clams and oysters). Domoic acid was identified when over a hundred Canadians were poisoned after eating mussels from Prince Edward Island in 1987.

Domoic Acid Intoxication



Nitzschia, *an algae that contains domoic acid, can be ingested by mussels and can cause serious illness in humans. In 1987, between 150 and 200 Canadians became ill after eating mussels. Because of this outbreak, new methods for surveying mussels were put in place.*

In November and December 1987, a mysterious illness related to the consumption of mussels from Prince Edward Island broke out in Canada. Between 150 and 200 Canadians became ill after eating mussels. While the majority of cases resulted in vomiting, diarrhea and cramps, a few were more serious. These resulted in neurological problems such as confusion, dizziness and memory loss. Four people, all elderly, died after eating the mussels. Although other incidents of illness associated with shellfish had been reported previously, the symptoms shown by the victims were new.[111]

Researchers found that the source of the illness was domoic acid in the mussel tissue. This happened as a result of an intense bloom of *Nitzschia*, an algae that contains domoic acid, in waters off eastern Prince Edward Island. The algae were ingested by the mussels, and accumulated in their tissue. While domoic acid is not harmful to mussels, it is toxic to humans in large enough amounts.

Health authorities responded to the epidemic quickly. When a number of people in Montreal were affected during November 1987, testing immediately began in Health and Welfare Canada's laboratories on samples of the contaminated mussels that were collected from homes and restaurants and tested in laboratories. These experiments showed that the mussels were highly toxic, and confirmed that the illness was a new one.[111]

At the same time that this research was being undertaken, health authorities were taking precautions to protect the public from further outbreaks. On November 29, distribution of mussels from Prince Edward Island was stopped, and shortly afterwards Canadians were advised not to consume mussels shipped from the province after November 1, 1987. Mussels were taken off the shelves in retail stores and removed from restaurants.

On December 3, a decision was made to test not only mussels from the eastern part of the province, but also shellfish from all Maritime coasts. The tests showed that most samples of the shellfish were safe. However, mussels from the Magdalen Islands in Quebec and oysters from New Brunswick did show signs of toxic chemicals. The tests for toxicity, along with the outbreak of illness associated with mussels, prompted the Canadian government to prevent the sale of all live clams, oysters, mussels and quahogs from Atlantic Canada until further notice. It was later discovered that the toxins in the Magdalen Island mussels and New Brunswick oysters were not concentrated enough to be harmful to humans.

Research continued, and on December 18, National Research Council Canada announced that a toxin, domoic acid, had been isolated from the toxic mussels. Investigations also showed that two mussel farms in the Cardigan River supplied 98 per cent of the toxic mussels.[111]

Once the toxin, its source, and its location had been identified, commercial harvesting of shellfish was permitted again in most Atlantic areas by February. Mussels from eastern Prince Edward Island were released for sale in April, when the levels of domoic acid had dramatically decreased.

Since the 1987 outbreak, shellfish in the Atlantic have been regularly tested for the presence of domoic acid. While mussels became contaminated again during the fall and winter of 1988, no illnesses were documented.

Micro-organisms in Drinking Water

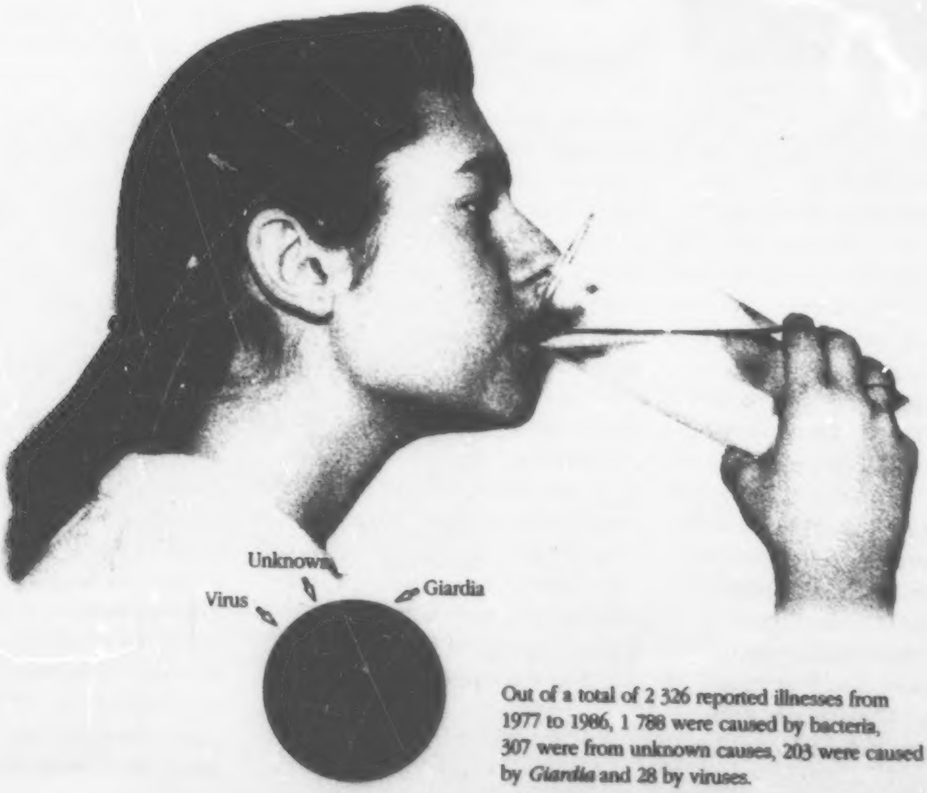
In the past, micro-organisms in water have been a major cause of disease in humans. In developing countries this problem persists and, in fact, water-related disease accounts for the death and disability of hundreds of thousands of people each year in these countries.

In developed countries such as Canada, community water treatment systems, which disinfect water and routinely monitor it for bacteria, have substantially decreased the risk of disease-producing micro-organisms contaminating our drinking water. However, in Native and rural communities, there is still too much waterborne illness. Native Canadians are admitted to hospital at seven times the rate for Canadians in general.

Although water treatment and testing is almost always effective, the risk of being infected from water does, however, still exist. Harmful viruses, bacteria or protozoa from human and animal wastes may find their way into the sources of drinking water. As well, many species of natural aquatic bacteria can colonize the water distribution system, so water is never entirely bacteria-free.

Typhoid fever, cholera, giardiasis, and infectious hepatitis are some of the diseases that can be transmitted in water. However, in Canada the number of reported cases of illness related to drinking water is very low. For example, between 1977 and 1986, only 42 waterborne outbreaks involving 2 326 people were reported (see figure 22, compiled from annual reports on waterborne diseases).[112] However, reporting is not mandatory, and such diseases may not require medical treatment and therefore may be difficult to trace. Reported cases show that bacteria such as *Campylobacter, Salmonella,* and *Shigella* have caused the greatest number of outbreaks involving more than one person, followed by unknown causes, *Giardia,* and viruses.

Figure 22
Causes of Waterborne Diseases in Canada



Out of a total of 2 326 reported illnesses from 1977 to 1986, 1 788 were caused by bacteria, 307 were from unknown causes, 203 were caused by *Giardia* and 28 by viruses.

Salmonella and *Shigella* are both characterized by the rapid onset of diarrhea and fever.

Campylobacter ***is among the types of bacteria known to have caused diseases from contaminated drinking water in Canada. The disinfection of drinking water is the main way of preventing such diseases.***

Viruses are one of the types of pathogens that can contaminate drinking water if it is not properly protected and treated. Norwalk viruses in contaminated drinking water can cause diarrhea in humans.

The hepatitis A virus may be transmitted by contaminated water. Overall, however, few people in Canada are believed to be infected by viruses through their drinking water; in 1983, only one outbreak of waterborne disease contracted from a virus was reported.[112] On the other hand, most virus infections from drinking water are believed to cause only mild stomach upset or fevers, and they often escape the scrutiny of public health officials.

Protozoa, one-celled parasitic organisms, can also be transmitted through water. The most common type of parasite to infect drinking water is *Giardia lamblia* which causes giardiasis, also known as "beaver fever." Giardiasis is a disease of the stomach and intestines. It is not fatal and is characterized by diarrhea, loss of appetite, dehydration, cramps and, in some cases, vomiting. Giardia may enter the water supply from human or animal waste.

Fortunately, modern sewage-treatment plants can greatly reduce the introduction of human wastes directly into raw water that is used as the source of drinking water. If, however, disease-producing bacteria do get into drinking water, a person's susceptibility to illness depends on a variety of factors. The type of bacteria is important, as only a small number of species cause human illness. The actual numbers of bacteria in the water must also be taken into account, for a few harmful bacteria may have no effect. The age and general health of individuals are also factors; children, the elderly, and people with chronic diseases are particularly susceptible.

In Canada, municipal water supplies are routinely tested for coliforms, a group of bacteria normally found in the intestines of animals and humans. Since they are generally the most abundant contaminating organisms, their absence indicates that disease-causing organisms are probably also absent, and that water has been adequately treated. In Canada, the water quality guidelines set by Health and Welfare Canada require acceptable drinking water to have fewer than 10 coliform organisms per 100 millilitres, none of which are to be fecal coliforms.[57]

Micro-organisms in Recreational Water

Micro-organisms can also occur in recreational water. In fact, the presence of bacteria that are associated with pollution is the most important indicator of water quality at recreational beaches.[21] People may be exposed to micro-organisms in recreational water by swallowing them or absorbing them through the skin. Disease-causing bacteria in recreational water may include *Staphylococcus aureus,* which can cause boils and infections of open wounds, *Pseudomonas aeruginosa,* which results in ear infections, and *Salmonella, Shigella,* protozoa, and intestinal viruses, which can lead to illnesses of the stomach and intestines. Most studies show that there is an increased risk of minor illness after a person has been in the water at the beach, no matter how good the water quality.

The *Guidelines for Canadian Recreational Water Quality* suggest limits to the concentrations of micro-organisms that are safe in recreational water. The goal of the guidelines is to ensure that water used for recreational purposes should be sufficiently free from fecal contamination, disease-producing micro-organisms, and other hazards that may pose a risk to the public.

Recreational water is tested for the presence of fecal coliform bacteria which serve as a general indicator of harmful micro-organisms in the water. The guidelines set limits of fecal coliforms or *E. coli* at less than 2 000 organisms per litre, and suggest that if these numbers are frequently exceeded, beaches should be closed.

Limits have been set for the amount of bacteria permitted in bathing beach water. High numbers of E. coli *are indicators of poor water quality.*

Recreational waters are a source of summer enjoyment. Guidelines have been developed to ensure that they are safe.

Micro-organisms in Indoor Air

Recently, scientists have realized that micro-organisms in the air may also cause illness. This is particularly true of indoor environments, where contaminants can accumulate in the air, and people can inhale them in relatively high concentrations. The most common such contaminants in indoor air are fungi, particularly moulds.

Fungi

Fungi need warm, moist conditions in which to grow. With our new concern over energy conservation, many homes and workplaces have been heavily insulated and tightly sealed to save both fuel and money. Unfortunately, these homes and workplaces are particularly susceptible to fungal contamination if they allow little air exchange with the outdoors and permit humidity to rise. Well designed homes and buildings are energy efficient. They have adequate ventilation with appropriate heating systems.

Many of the products of fungi – spores, mycotoxins and volatile chemicals – can be harmful to human health. Many moulds are capable of producing large numbers of spores in a short time. These spores are released into the air and may cause allergies or sensitivities in some people. About 10 to 15 percent of the population is allergic to fungi.[115]

Some types of fungal spores can cause lung diseases or diminish the response of the immune system. In people who have greatly reduced resistance to disease, the fungi may infect the body in a more pervasive way, and thus affect other tissues and organs.[116]

Some fungi may also produce compounds known as mycotoxins, chemicals that are toxic to humans. Mycotoxins can cause serious lung damage to people. A study done during the 1970s demonstrated that workers in a silo who inhaled mycotoxins had lung damage, known as "atypical farmer's lung." There is also some evidence that inhaling spores of fungi that produce toxic substances called aflatoxins can lead to liver cancer.[115]

Scientific studies provide convincing evidence to support the view that inhaling mycotoxins can be a health risk. In certain buildings when people inhaled mycotoxins, produced by the fungus *Strachybotrys atra*, adverse health effects were documented. In a home in Chicago, for example, where *S. atra* had accumulated in the air-conditioning ducts, the occupants suffered from a variety of maladies including cold and flu symptoms, sore throats, headaches, fatigue, dermatitis, and general malaise. When the fungus was removed, the occupants of the home recovered.[115]

Fungi also produce volatile compounds that are recognized by most of us as mouldy smells. So far, there is little known about their effects on health. However, some people do seem to have respiratory responses to these mouldy smells, ranging from a feeling of stuffiness to wheezing.[116]

Epidemiological studies conducted in Canada, the United States, and Great Britain demonstrate that respiratory symptoms increase in damp homes. While this may suggest that the presence and inhalation of fungal spores is definitely linked with respiratory illness, other factors are involved. Moisture and dampness in a home may also cause problems. For example, condensation in a house often means that it has inadequate ventilation; this leads to high concentrations of whatever pollutants are in the house, including volatile organic compounds and combustion gases. Dust mites in the home may also have an impact on respiratory health.[115]

Bacteria

Although fungi in indoor air are more common contaminants than bacteria, these may also have harmful health effects. Bacteria grow directly in water, rather than in the damp conditions that support the growth of fungi. Unlike fungi, bacteria do not produce airborne spores. Instead, they must be dispersed indoors in aerosols (minute droplets of water that are suspended in air).

The two main sources of bacteria are aerosols from people or animals, and aerosols from water sources such as humidifiers, showers and faucets. Bacteria transmitted into the air by humans or animals are generally expelled by sneezing, coughing or speaking. These bacteria may survive for significant periods of time, depending upon the droplet size, the air temperature, and the relative humidity.

Waterborne bacteria in the outdoor environment can increase and spread within the home, and cause disease. For example, certain types of bacteria can accumulate in humidifiers and cause "humidifier fever," an allergic response to the airborne bacteria. These bacteria may cause pneumonia in a person whose immune system is not working well.

Legionnaires' disease is another illness caused by airborne bacteria. *Legionella* bacteria grow well in warm water rich in organic material such as poorly maintained air-conditioning systems in large buildings. When *Legionella* is spread as an aerosol, it can enter the human respiratory tract. In most cases, it may only cause milder "flu-like" symptoms known as Pontiac fever; these symptoms disappear without medical treatment. Occasionally, however, these bacteria may cause pneumonia, and can be fatal. Because *Legionella* is not always extremely infectious, it is apparent that different strains of the organism have varying abilities to cause disease, and that people have different levels of resistance to it.[116]

Viruses

Unlike fungi and bacteria, human viruses cannot grow outside their human hosts. Thus, the spread of viruses in the indoor environment depends very much on human activity. However, indoor-air factors such as relative humidity, temperature, and the presence of other pollutants may have some bearing on the survival and transportation of airborne viruses.

In 1987, Health and Welfare Canada published *Exposure Guidelines for Residential Indoor Air Quality*. These guidelines suggest that in order to prevent illnesses from indoor-air contaminants, measures should be taken to eliminate excess humidity and condensation, to keep surfaces free from dust, and to ensure that stagnant water sources – such as humidifier tanks – are kept clean and frequently disinfected. The guidelines do not recommend limits on the levels for micro-organisms in indoor air, as there is still much research to be done before such recommendations can be made.

One of the practical uses of biotechnology is to help clean up the environment. An example of this is the use of genetically modified micro-organisms to help disperse oil spills.

Biotechnology and Genetically Engineered Micro-organisms

Since the mid-seventies, biotechnology has become one of the most important areas of scientific advancement in Canada and throughout the Western world. But just what is biotechnology?

While biotechnology is a very large field of knowledge that is constantly expanding, it can generally be defined as the use of living organisms or parts of living organisms – usually micro-organisms, plant cells or animal cells – to manufacture goods that are useful to people.

The rapid growth in biotechnology has, however, been accompanied by ethical questions and considerations about the impact of biotechnological products on the ecosystem and on human health.

Some of the concepts underlying biotechnology are very old. For example, the use of live bacteria in cheese-making and yeast in bread are early forms of biotechnology, in which the qualities of living organisms are utilized to manufacture a product. Today, however, scientists have gone far beyond these simple applications to procedures that involve combining life forms in different ways.

Genetic Engineering

The rapid growth in biotechnology has been fuelled by the development of genetic engineering, also known as genetic manipulation, gene splicing, or gene cloning. In genetic engineering, scientists modify or create new, simple forms of life.

Currently, most genetic engineering uses micro-organisms, also called microbes. They are tiny organisms such as bacteria, yeast, and algae, that can be found almost everywhere in the environment. Each of these micro-organisms consists of just one cell. The human body, in comparison, contains about 100 billion cells.[117]

Despite their small size, micro-organisms are extremely adaptable and resilient. Each cell consists of thousands of different types of chemicals, most of which are very complex. All of these substances must be constructed from the relatively simple building materials that the micro-organism finds in its environment. Complex chemicals cannot be built up from these simple materials in one step. Instead, each cell takes in raw materials and makes a succession of small changes to them, until the final product is completed. Each micro-organism is an independent entity that can perform all the functions needed to keep it alive and allow it to reproduce.[117]

DNA

The substance that makes these chemical processes possible is deoxyribonucleic acid, known as DNA. DNA is the basic hereditary material for all living organisms, from one-celled micro-organisms to humans. It is made up of genes which contain the instructions for creating the chemicals – enzymes, hormones, proteins – that an organism needs to survive.

Genetic engineering involves taking the DNA from one organism and implanting it into another "host" organism, usually a bacterium. This host organism will then make the desired proteins at the same time it makes its own. Essentially, genetic engineering confers on an organism some capability originally found in another. Often genetic engineering is referred to as "recombinant DNA research," as it involves "recombining" the DNA – and therefore the properties – of one organism with the DNA and properties of another.

The Process

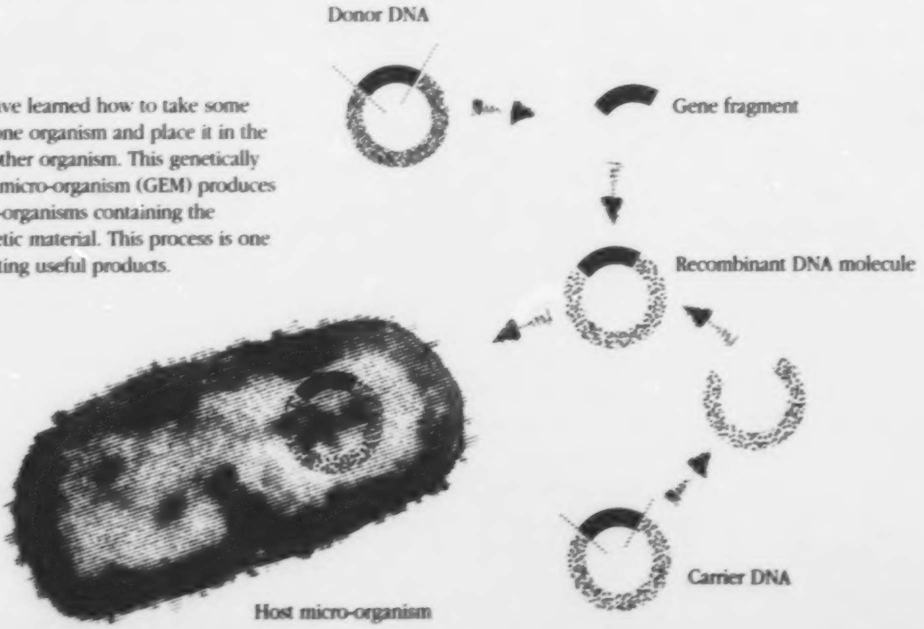
There are several stages in the process of genetic engineering (see figure 23). First, a scientist must isolate the gene to be used, whether it is from a plant or animal cell, or from a micro-organism. This gene will have capabilities or qualities that the scientist wants to reproduce in another micro-organism. That gene is then inserted into a micro-organism. Once the scientist has a number of micro-organisms that contain these foreign genes, the micro-organisms are placed in vats with nutrients so that they will reproduce, something they do very quickly. The new micro-organisms will also contain the foreign gene. These genetically engineered micro-organisms (GEMs) are used in a variety of ways.

In some cases, the chemicals the new GEMs create are collected and used; in other cases, the GEMs themselves are employed for their particular capabilities.[117]

These new organisms have a number of practical and beneficial uses. For example, GEMs can be used in the pharmaceutical industry to manufacture new drugs. Human insulin, required by diabetics, is already being made through biotechnology, as is the human growth hormone needed by children with congenital deficiencies. GEMs can also be helpful in agricultural practices, acting as alternatives to chemical pesticides and herbicides. They can be applied in manufacturing industrial chemicals, and have great potential for cleaning up pollution in the environment.[118]

Figure 23
Genetically Engineered Micro-organisms

Scientists have learned how to take some DNA from one organism and place it in the DNA of another organism. This genetically engineered micro-organism (GEM) produces more micro-organisms containing the altered genetic material. This process is one way of creating useful products.



Potential Health Effects

Most of the steps just described take place in the laboratory. However, we must guard against adverse health or environmental effects when these new organisms are allowed to enter our environment by being sprayed on crops or applied to oil spills.

The quantity of GEMs entering the environment depends on a number of factors. An accident in a laboratory might release only a relatively small number of micro-organisms. A field trial, in which the capabilities of a new strain of micro-organism are being tested might mean a somewhat larger release. The application of GEMs to an oil slick or to crops would mean the release of large numbers of these organisms.

Some scientists are concerned that once these genetically engineered micro-organisms enter the environment, they may pose a risk to human health. They argue that some GEMs may have new properties not found in nature, and therefore the environment and humans would not be properly prepared.

Arguments against the introduction of GEMs into the environment include speculation that some GEMs may be toxic, produce sensitivity or allergenic reactions, or infect and cause disease in exposed people.[118] This may be particularly true for people directly applying GEMs in the environment – that is, those who are occupationally exposed. However, people in the direct vicinity of an area where GEMs are being used could possibly also be exposed.

On the other hand, many scientists believe that GEMs will not pose any significant hazard. This is because GEMs differ little in their

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Biotechnology Regulations

The Canadian Environmental Protection Act (CEPA) was developed primarily to better identify and control chemical contaminants in the environment. However, the legislation also applies to biotechnology products. The Act complements other legislation dealing with biotechnology, and will ensure that biotechnology products are assessed before being used, and controlled where necessary.

The Act, passed in 1988, is administered jointly by Health and Welfare Canada and Environment Canada. These departments are preparing regulations under CEPA that will require companies to provide information to the government about a product and its safety before it can be manufactured, introduced into the environment, or imported into Canada.

Companies must supply the government with information about their products, including:[119]

- the identity of the micro-organisms and characteristics of a product,
- data about the product's environmental effects,
- data from tests to assess the product's effect on human health, and
- a description of intended uses and manufacturing methods.

Health and Welfare Canada will assess the information and determine if any of the products require further testing or should be controlled to ensure health protection. The assessment will consider the answers to such questions as:

- Has the organism been involved in human disease?
- Is the organism capable of infecting people, or does it produce any compounds that could be toxic?
- Will using the organism lead to unusual ways of exposing people or to unusual levels of exposure? Will such exposure be harmful?

Because of public concern about genetically engineered organisms, particular attention will be paid to assessing what genetic modifications have been made to an organism, and the effects of the changes. If these products are examined before being introduced into the environment, there should be a greater assurance of their safety.

basic make-up from naturally occurring micro-organisms that exist everywhere in the world and have been used extensively in the past, for example in agriculture. Many scientists and policy-makers also point out the fact that the potential benefits to health from GEMs far outweigh the risks. For example, by increasing crop yield or cleaning up polluted water and soil, GEMs can improve human health.

Assessment and Control

Health and Welfare Canada believes assessment of possible hazards of such products before they are used is the wisest path to follow. There should be assurances that a GEM, like any strain of micro-organism used in a biotechnology product, should be tested to ensure that it is not toxic or pathogenic (causing disease).

In Canada, a number of federal acts are or will be used to protect human health and the environment from possible adverse effects of GEMs. The first is the Food and Drugs Act, administered by Health and Welfare Canada. This Act is used to regulate the safety of food and food additives which Canadians eat. With the potential use of micro-organisms in food and its preparation, the Act will be used to regulate food contaminants and residues produced through biotechnological processes.[120]

Great advances are being made in the use of GEMs for pharmaceuticals. GEMs used in this capacity will also be regulated through the Food and Drugs Act.[120]

The Pest Control Products Act, administered by Agriculture Canada, now is used to regulate the use of naturally occurring organisms such as pesticides, and to ensure that these organisms are not harmful to the health of the people who work with them or to the general public. Under this Act, Health and Welfare Canada is responsible for evaluating the safety of pesticide micro-organisms that are genetically manipulated.[120]

The Canadian Environmental Protection Act (CEPA) ensures that new substances (such as GEMs) that are not covered under other federal legislation will be assessed for potential health and environmental effects. This includes GEMs used for pollution control, mineral recovery, and waste disposal, as well as many other purposes.[120]

There are a number of other guidelines and standards to protect against possible adverse health effects of the use of GEMs. For example, the Medical Research Council of Canada, along with Health and Welfare Canada, has created the *Laboratory Biosafety Guidelines* for research laboratories in universities, hospitals, industry and government, where potentially pathogenic micro-organisms are being used. These guidelines do not apply to environmental use in agriculture and industry. However, they do ensure that GEMs are restricted from entering the environment through any kind of accidental release from research laboratories. The guidelines also protect laboratory workers exposed to GEMs.[121]

Chapter Six
Radiation

Radiation is all around us at all times. It beams down on us from the sun and from space and is constantly being given off by various elements in the earth. Scientists refer to this as background radiation, and it is an inescapable part of life on this planet. High-energy radiation is referred to as "ionizing," while radiation of lower energy is generally known as "non-ionizing."

In recent times, we have added to background radiation by generating power, using X-rays for diagnostic and other purposes, developing nuclear medical practices and other nuclear technologies, and testing and maintaining nuclear arms. Increases in radiation from weapons testing and from nuclear power production currently add only a small fraction to the natural background exposure. On average, medical uses now contribute 40 to 50 percent of each person's exposure to radiation.

The buildup of gases that deplete the ozone layer high above the earth's surface in the upper atmosphere also contributes indirectly to radiation at ground level. This stratospheric ozone layer usually absorbs ultraviolet (UV) radiation from the sun; if the ozone is depleted, more radiation will reach the ground. As discussed previously, increased UV radiation from depleting ozone in the stratosphere increases the possibility of skin cancer.

X-ray imaging techniques have permitted major advances in health care. They are used routinely in medical and dental practice.

Some occupations, such as mining or working in the nuclear power industry, may potentially expose workers to higher levels of ionizing radiation than the average person. Because of this, many precautions have been developed over the years to protect workers from on-the-job exposure. As an example, the federal government operates the National Dosimetry Service to monitor the levels of radiation exposure of individual workers, and the National Dose Registry to record these radiation doses.[124, 125]

Ionizing Radiation

Because of its higher energy, ionizing radiation can dislodge electrons from molecules in the body, forming ions. The ions may then be able to act in ways that they were not able to do before the radiation hit them. Figure 24 shows a wide range of health effects, regulatory limits, and examples of everyday radiation exposures. Ionizing radiation can cause a breakdown within the cells of living organisms, causing changes that could possibly lead to cancer.[126]

National Dose Registry

The National Dose Registry is a central computerized record system that keeps track of radiation doses for workers across Canada. The Registry was first begun in 1951, as part of the National Dosimetry Service, a program of Health and Welfare Canada. Since that time the Registry has greatly expanded and diversified. It contains dose records for approximately 350 000 individual workers. Of these, approximately 100 000 are still being monitored.[125] These include dentists, radiologists, workers at nuclear power stations, industrial radiographers, and uranium miners.

The records have proven to be an invaluable tool in a number of ways. They can be used:

- in epidemiological and risk-related studies. For example, the records are being used in a large-scale study of the deaths of workers who are exposed on the job. Annual reports summarizing doses in Canada by region and occupation have been published every year since 1977. These reports are used by various authorities to identify areas of potential concern.
- to assist authorities in regulating the amount of radiation to which a worker is exposed. In cases where a worker's dose exceeds regulatory limits, the employer and the appropriate authorities are notified. The Registry is particularly useful for this purpose because, regardless of how many times a person changes jobs, any reported radiation dose will be added to the centrally located record.
- for information and legal purposes. The Registry is an official government data bank and is covered by the Privacy Act which limits the uses to which the data can be put. The dose records from the Registry have been supplied as evidence of exposure in legal and compensation cases.

Radiation can kill cells directly, as well as disrupting their functions; this is the basis of cancer treatments using radiation.

Acute doses of ionizing radiation destroy the body's defence systems against infection; they may also affect the central nervous system and disrupt the functions of the stomach and intestines. Lungs, skin, eyes and certain glands are particularly susceptible to damage, as are developing fetuses.[129]

With lower doses, a person may develop eye cataracts or various sorts of cancer – including bone, lung, thyroid, and breast cancer, or leukemia. Cancers produced as a result of radiation appear similar to cancers caused by other sources; it is not possible for a surgeon or pathologist to identify the cause of a cancer by examining the cancerous cells.

Ionizing radiation in sufficient doses has the potential to alter genetic material. This means that while the irradiated person may suffer no ill effects, hereditary defects may appear in future generations.

It is extremely difficult for scientists to identify radiation as the cause of cancer and birth defects. Because of the long period of time involved between the initial probable exposure and the onset of cancer, scientists face a demanding and complex process when they try to determine risk by measuring the dose and length of exposure received by specific groups of people. Cancer may take from two to more than 20 years to develop.

Beneficial Uses

Ionizing radiation also has very beneficial applications. Two examples are X-rays used for medical diagnoses, and minute amounts of radioactive substances used as tracers in nuclear medicine.

X-rays, used both in medical diagnosis and in certain industrial applications, are the most common way a person is exposed to ionizing radiation that does not come from natural sources. As well, the general population is potentially exposed to X-rays from certain consumer and industrial products. In order to prevent adverse health effects, the use of X-rays is strictly regulated.

X-ray equipment of various sorts (including baggage-checking equipment at airports) is regulated in terms of design, construction, performance and use. Under the Radiation Emitting Devices Act, the federal government is responsible for regulating the equipment itself. As well, the federal government publishes safety codes, although regulating the installation and use of X-ray equipment falls under provincial jurisdiction.

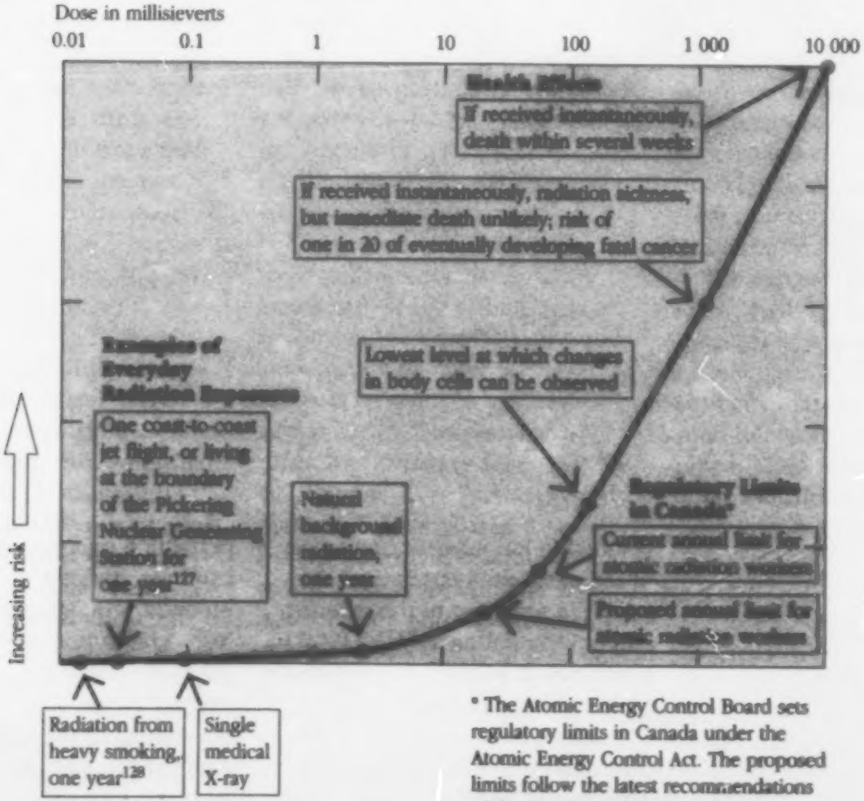
Televisions and computer monitors have at times been suspected of being dangerous because of the possibility of radiation from their screens. Therefore they have been extensively investigated. This has resulted in government regulations so that these machines do not emit measurable amounts of X-radiation during use.[130]

Pollution, Monitoring and Response

Some of the radioactive isotopes of the chemical elements occur naturally, such as those of uranium. Others are produced by human activities. Manufactured radioisotopes may reach the environment from industries involving nuclear power, the manufacture of nuclear weapons, or nuclear medicine.

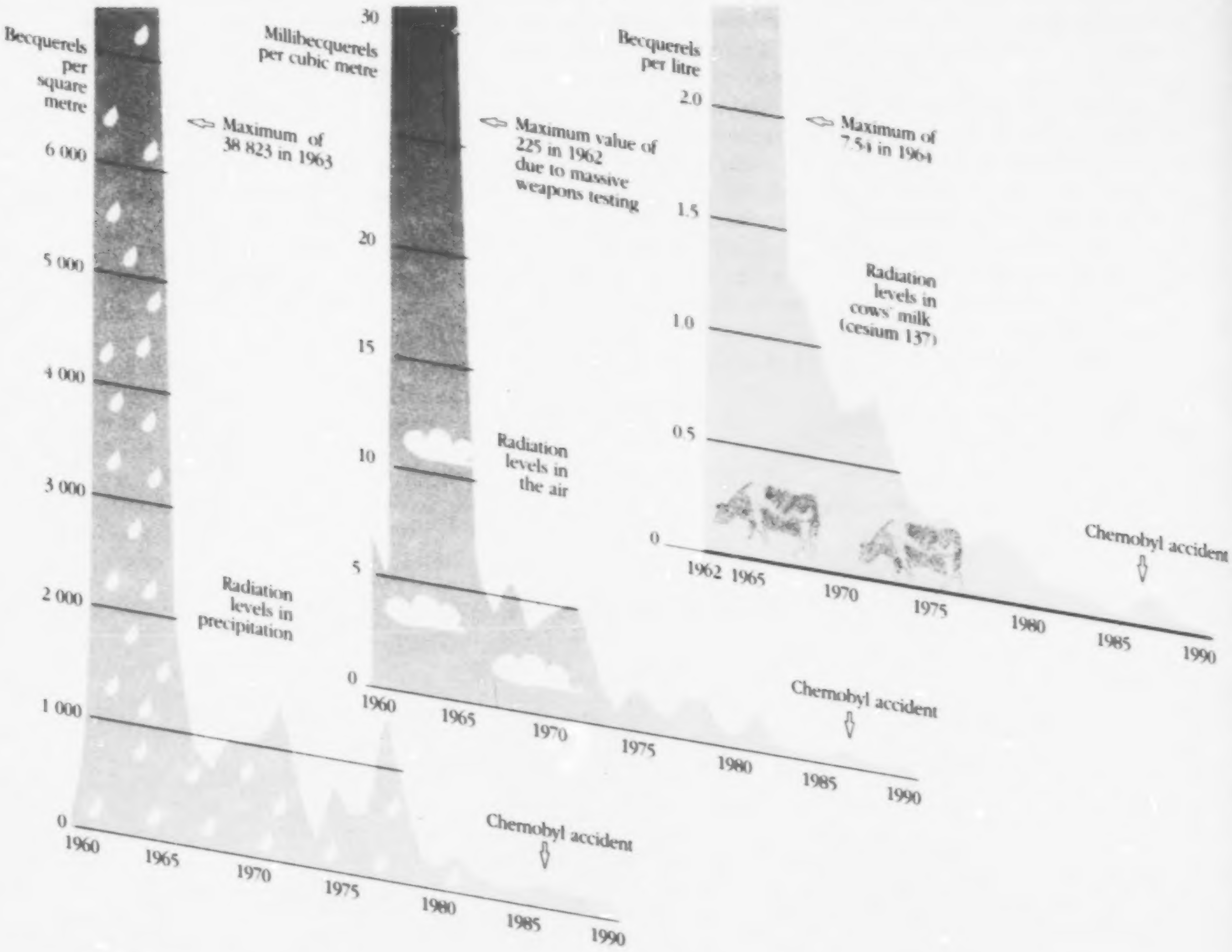
The earliest source of widespread radioactive pollution was the testing of nuclear weapons in the atmosphere. The tests

Figure 24
Radiation Exposures and Limits



* The Atomic Energy Control Board sets regulatory limits in Canada under the Atomic Energy Control Act. The proposed limits follow the latest recommendations of the International Commission on Radiological Protection. The annual limits for the public control the exposure from regulated nuclear facilities such as nuclear reactors. These limits are in addition to the natural background radiation.

Figure 25
Trends in Environmental Radioactivity in Canada, Yearly Averages[131]



resulted in long-distance transport of radioactive fall-out around the world. In response to this, the federal government in 1956 established a network of stations across Canada to monitor the fall-out.

Concern over the effects of fall-out resulted in the signing of the 1963 Partial Test Ban Treaty, which effectively ended major atmospheric testing of nuclear weapons, while permitting underground tests to continue. Although some above-ground testing did continue, it is far less significant in terms of spreading radioactivity than testing between the end of World War II and the signing of the treaty. The last atmospheric tests were carried out by the People's Republic of China in the 1970s and in 1980.

The amount of radioactive fall-out in our environment decreased rapidly after 1963. Now, residual fallout is barely detectable, being much less than the natural background.

Figure 25 illustrates the decline in radioactivity in the air and in precipitation over the years, and of cesium-137 – a product of nuclear fission – in cows' milk. This radioactivity, which is released into the air, gets into precipitation and eventually ends up in foods, such as milk, that are consumed by humans.[131] The high levels in the early sixties were due to the above-ground testing of nuclear weapons.

When nuclear power generating stations were built in Canada, the federal government also set up monitoring networks near the plants. The generation of power by nuclear reactors has contributed very little radioactive pollution to the environment in Canada.

There have been three accidents affecting Canada involving nuclear reactors, although the reactors were not Canadian. In 1978, the Soviet satellite Cosmos 954 disintegrated during its re-entry through the atmosphere. Radioactive material was widely dispersed over parts of the Northwest Territories, but did not present a great hazard to health.[132, 133]

In 1979, the nuclear power station at Three Mile Island in Harrisburg, Pennsylvania, had an accident that released radioactive gases into the atmosphere. Contaminated water containing radioactive iodine was later released into the nearby Susquehanna River. This accident had no direct physical impact in Canada, but did prompt the development of a plan to deal with future incidents. This plan is called the Federal Nuclear Emergency Response Plan, and includes a network for monitoring, gathering information and putting into place appropriate action in the event of a nuclear emergency.[134, 135]

More recently, in 1986, a fire at the Chernobyl nuclear power plant in Ukraine caused illness and death in workers at the site and great public concern around the world. Most of the contamination from this accident fell in Ukraine, Byelorussia, and Russia. Some contamination reached Scandinavia and western Europe, but the accident had very little effect in North America.[136, 137]

Under normal circumstances, there is very little radioactivity in food produced in agricultural areas. However, traditional Native foods are now being monitored, particularly in the Arctic, as the growing conditions are rather different. For instance, cesium-137 is taken up by caribou because they graze on lichens, and is detected in caribou meat. A recent study of people who eat caribou meat has shown that the amount of cesium-137 in the meat is low, and these consumers are at a very low risk.[138]

Drinking water also contains some radioactivity. Water taken from rivers or lakes contains some residual fall-out, but in only trace amounts, while water from wells can contain uranium, sometimes at high levels. The *Guidelines for Canadian Drinking Water Quality* include guidelines for the concentrations of these radioisotopes. Guidelines for the control of all other radioisotopes in food and water are not normally necessary, as they are present in only trace concentrations, or absent altogether; however, guidelines are being prepared to specify the tolerable concentrations of radioactivity in food and water in the event of a nuclear emergency.

Radon

A colourless gas occurring naturally throughout the world in rocks, soils and ground water, radon can be the source of some radioactivity in indoor environments. Levels of radon are not considered a serious problem in the vast majority of Canadian homes.

Radon is a product of the radioactive decay of uranium, a metallic element common in the earth's crust. The amount of radon in a home is determined by the uranium content of the surrounding soil and the permeability of the soil for transport. It seeps through dirt floors, cracks in concrete walls, basement drains, and joints. Well waters may also be a significant source. Radon can enter any confined space and, if it occurs in sufficient concentrations, may be a health hazard.

The danger is not actually from radon itself. As an inert gas, it is breathed in and out of the lungs without significant interaction. The biological danger arises from the solid radioactive decay products of radon. These products give off alpha radiation that is disruptive to processes in living cells.

Radon in Canadian Homes

Investigation of the presence of radon in homes grew out of studies of workers' homes in the uranium mining communities of Elliot Lake and Bancroft in Ontario and Uranium City in Saskatchewan. The Atomic Energy Control Board (AECB) measured the presence of the radioactive gas in these communities because of suspected contamination.

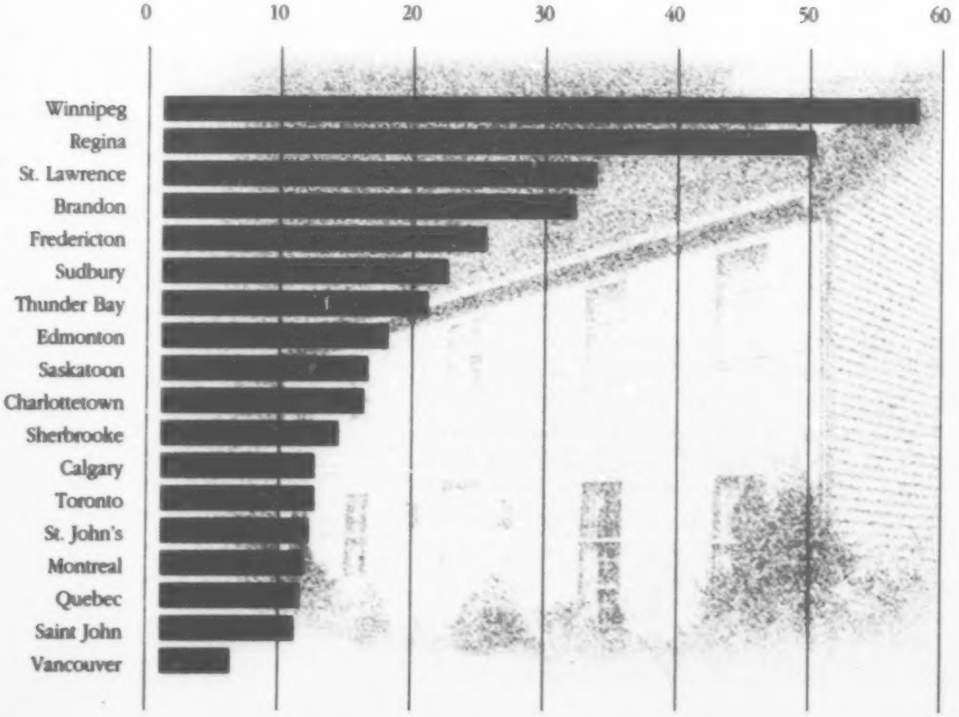
What they discovered surprised them. It quickly became clear that radon levels in homes did not relate to the presence of contamination from radium, a radioactive decay product of uranium. While some radioactive contamination was found in the form of mine waste or refinery residues, when this material was removed from the homes, radon levels did not change.[122] In other words, the measured radon levels in the homes in these communities were due to natural radon sources and not to something put there by the technology of uranium mining and refining.

The AECB results sparked interest in studying radon levels in Canadian homes generally, to determine what "normal" levels were and to see if there were any variation of levels from city to city and within cities. Thus, a total of 14 000 homes in 19 cities were surveyed in the summers of 1977, 1978 and 1980 for radon levels.

The researchers did find significant differences in radon concentration in Canadian homes when compared on a city-by-city basis. In figure 26, the concentrations are shown in becquerels per cubic metre of air, shortened to Bq/m³. Radon concentrations vary from 57.0 Bq/m³ in Winnipeg to 5.2 Bq/m³ in Vancouver. (Results from Halifax were not available.) This survey also provided no evidence of a relationship between radon levels and lung cancer, although this link has been measured for uranium miners exposed to higher levels on the job.

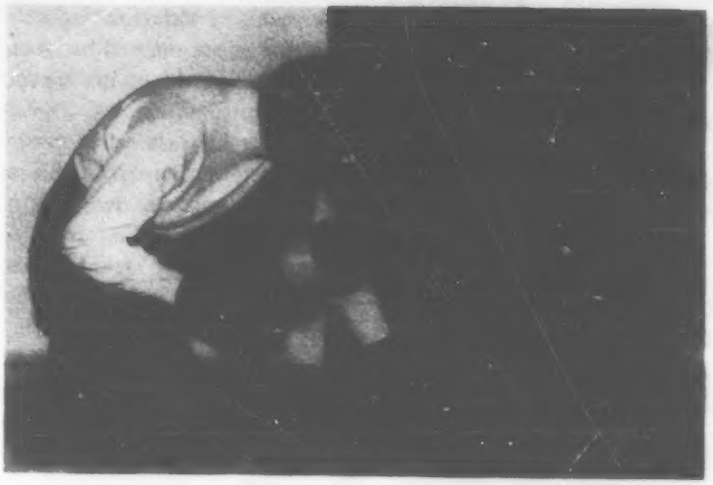
A study is under way by Health and Welfare Canada, seeking to clarify possible links between levels of radon in the home and lung cancer.[139] The population being studied is 750 newly diagnosed cases of lung cancer in Winnipeg. These people are being interviewed to determine important exposures to carcinogens in their lives, including their residence and work histories. Where possible, radon levels are being tested in the home or homes where these cancer patients have lived. As well, a similar group of people, matched by age and sex, with no lung cancer are also being interviewed and their houses tested. This study seeks to determine in quantitative terms the effect of radon exposure in homes on the risk of lung cancer, taking into account the effects of other factors.[139]

Figure 26
Levels of Indoor Radon in Various Canadian Cities[139]
(becquerels per cubic metre)



Results for Halifax are not available.

Human skin is thick enough not to be affected at the concentrations found in air, but bronchial and lung tissue is not. If a person breathes radon decay products, there is some risk that the alpha radiation may damage lung tissue and cause cancer. Canadian studies of uranium miners during the 1970s, for instance, showed a relationship between radon exposure and increased risk of lung cancer.



There are several methods for measuring radon in the home. Measurement can be done by air specialists, or sampling kits can be used by the homeowner and sent to a private laboratory for analysis.

How to Test for Radon Levels in Your Home

Health and Welfare Canada considers that radon pollution is not widespread in Canadian homes. Studies indicate that less than 0.1 percent of homes in Canada may have radon levels that may warrant remedial action. Moreover, new ventilation standards, as well as construction guidelines in the National Building Code, address radon buildup in new construction. Nevertheless, if you would like to check your home for radon levels, inexpensive tests are available.

Many home-owners say that they prefer a quick measurement of radon levels rather than a more accurate test that would take time to complete. Thus, a screening test is used – a short test that will give a general idea of radon levels without taking much time. An example of this kind of screening test is a gas-absorbing charcoal canister that is opened and left exposed for a two-day period. The canister is then sent away for laboratory analysis and the results mailed back to the person whose home was tested. Usually the basement of the house is chosen as the test site because the highest radon levels are found there. This kind of test costs approximately thirty dollars.

If the results of the first test indicate elevated levels of radon, you may want to repeat the procedure and compare results. It may be more advantageous to try a long-term radon measuring device to determine radon levels over an extended time. Indeed, some people prefer to use this kind of test initially. These tests are done in the living area of the house and the device is placed where it will be exposed to normal air circulation.

Measurements made by Health and Welfare Canada and other researchers have shown that a six-month measurement using a long-term radon dosimeter will provide a good representation of the annual concentration. An example of this measuring device is the alpha track detector that may be exposed to the air for a minimum of three months and up to one year, and also costs about thirty dollars. This device is also returned to the supplier for lab results at the end of the exposure.[140]

If the radon level in a dwelling exceeds 800 Bq/m^3 as the annual average concentration in the normal living area, Health and Welfare Canada and the provincial ministries of health recommend that remedial measures be taken to reduce these levels. Because there is some risk at any level of radon exposure, home-owners may wish to reduce levels of radon to as low as practicable.

Reducing radon in your home requires an understanding of how it is entering. No two structures are alike in terms of radon penetration since house design, atmospheric conditions and ventilation rates can all affect radon entry. Canada Mortgage and Housing Corporation has a number of documents on radon in housing in a publications series for consumers and builders.

Non-Ionizing Radiation

Non-ionizing radiation is a lower-energy form of radiation that does not have the capacity to dislodge electrons and affect cells. It can, however, produce heat in human tissue in that way, so exposure to some types of non-ionizing radiation may be hazardous. These types include infra-red radiation and microwaves.

The sun's natural ultraviolet rays can cause chemical reactions within cells that may be harmful to skin and eyes if a person is exposed to direct sunlight for too long. This also applies to sunlamps and tanning booths, which employ the same kind of ultraviolet radiation. The strongest ultraviolet light from the sun is emitted between 10:00 a.m. and 4:00 p.m., especially during the summer.

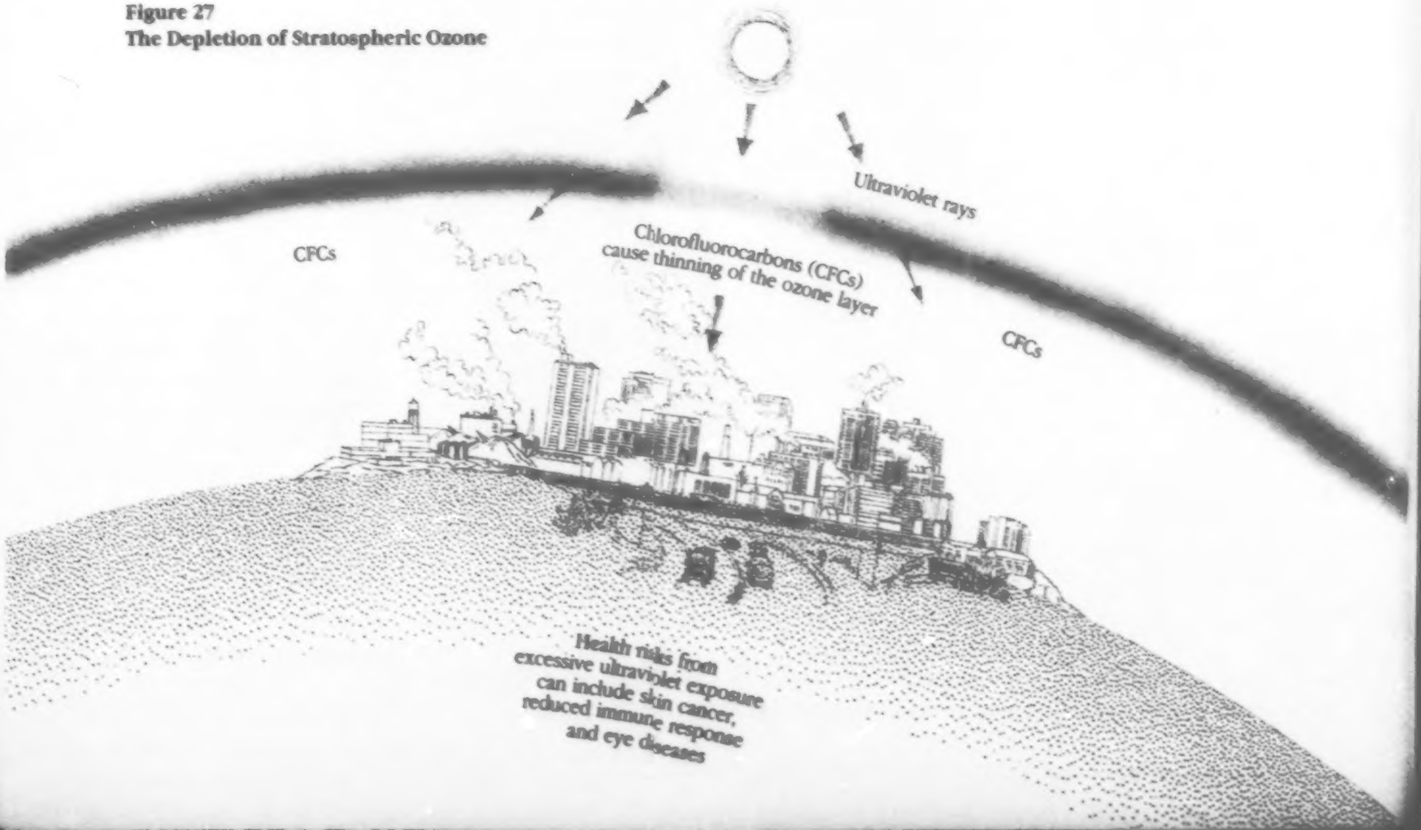
The potential for health problems is one of the reasons for public concern over the depletion of ozone in the stratosphere. This gas in the stratosphere absorbs ultraviolet radiation and stops it from reaching the ground. Thus, when ozone is depleted, more ultraviolet radiation reaches the earth's surface (figure 27). This can lead to an increase in skin cancer, the most common type of cancer in Canada.

Ultraviolet radiation is also given off by welding arcs, germicidal lamps, ultraviolet lasers and certain kinds of industrial inspection processes.[141]

Overexposure to ultraviolet radiation can also result in very painful and disabling inflammations of the eyes; however, these inflammations last only a few days, with no remaining lesions. In the long term, overexposure to ultraviolet light may lead to cataract formation. It may also trigger Herpes Simplex of the eye, or erosions of the cornea. People experiencing such problems should protect their eyes.

Microwaves also may be hazardous because of their ability to penetrate and produce heat in human cells, so there are strict safety standards for equipment and consumer products using microwaves.[142]

Figure 27
The Depletion of Stratospheric Ozone


Ultraviolet rays
CFCs
Chlorofluorocarbons (CFCs) cause thinning of the ozone layer
CFCs
Health risks from excessive ultraviolet exposure can include skin cancer, reduced immune response and eye diseases

Electric and Magnetic Fields

Electricity is an essential part of modern life. Wherever there is electric power, there are electric and magnetic fields. The electric power that we use in our homes, offices and factories uses AC, or alternating current. An alternating current does not flow steadily in one direction, but alternates back and forth. The power we use in North America, which alternates 60 times each second, is called 60-hertz (Hz) power.

Electric and magnetic fields are associated with all electrical power. These fields are created by electric charges. Charges produce two kinds of fields: electric fields, which result from the strength (voltage) of the charge, and magnetic fields, which result from the motion (current) of the charge. Taken together, they are referred to as electromagnetic fields (EMFs).

The strength of an electric field depends on the voltage. For example, a high-voltage power line usually produces stronger electric fields than a low-voltage power line. An electric field can exist even if a current is not flowing in an object, as long as it is plugged in. For example, an electric blanket that is plugged in but not operating may still produce an electric field.

Currents produce magnetic fields. Since magnetic fields are created only when current is flowing, appliances that are plugged in but turned off do not produce magnetic fields.

Scientists have found that fields can produce a variety of behavioral and physiological changes, such as changes in the levels of specific biochemicals, and changes in the functioning of individual nerve cells and the nervous system.

There have also been studies of people who are exposed to fields in their normal course of living and work. Some studies have suggested there may be an association between field exposure and certain forms of cancer. Other studies have shown no such association. To date, the evidence has been inconclusive.[143]

Population Studies

Epidemiological studies of various groups of people can only demonstrate an association between exposure to 60-hertz fields and various diseases, not a cause-and-effect relationship. All of the studies involve some level of statistical uncertainty.

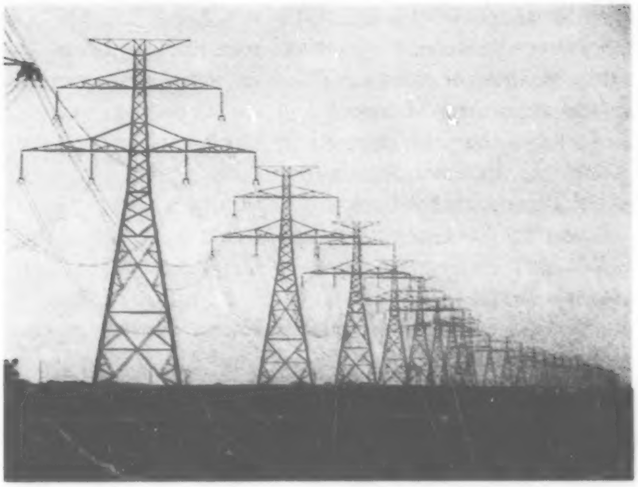
A relationship between childhood cancer and nearness to distribution power lines was first reported in 1979. A case-control study compared the exposures of 344 children who had died of cancer from 1950 to 1973 with a similar number of children born at the same time who did not get cancer. The conclusion was that children from homes near multiple, heavy, high-current power lines (high-current configuration wiring) were two or three times as likely as those from homes near low-current configuration wiring to develop cancer, particularly leukemia, lymphomas, and nervous-system tumours.[144] Researchers assumed that there was an association between the wiring configuration and exposure to magnetic fields.

This study was repeated as part of the New York Power Lines Project. More than 500 houses were measured for fields. The researchers found an association between cancer and wiring configuration, but not with actual measurements of fields. The study was controlled for other relevant factors (such as traffic density near the homes) that may have a role to play in cancer.

Both these studies, which involved different groups of children, reported an increase in the incidence of childhood leukemia in homes close to heavy-duty distribution lines. Other studies demonstrated that these lines typically produced strong magnetic fields.[145]

Four other studies have also looked for links between EMFs and childhood cancer – with mixed results. One found no increased risks at all for children living close to power lines; another found increased risks of nervous-system cancers and lymphomas but a decreased risk for leukemia; and two others found higher risks for various cancers, but the numbers were not statistically significant.[144]

Although a majority of the studies on childhood cancer and EMF exposure have found at least some relationship, studies of adults living close to power lines have generally not found any. In contrast, epidemiologists have found that workers in various electrical occupations have higher risks for various types of cancer, particularly brain and nervous system cancers, as well as leukemias.



Electric transmission lines carry high-voltage electricity needed to meet the high demands of modern society. The strength of the electric field depends on the voltage in the lines.

Another widely noted study, performed at the Johns Hopkins University, found a dose-response relationship for cancers in male New York Telephone employees from 1976 to 1980. The average magnetic field exposure was measured among different types of employees; cable splicers received, by far, the largest doses, followed by central office employees, and then installation and repair workers.[144] The cable splicers were nearly twice as likely to contract all types of cancers, with leukemia and lymphomas being particularly high. The central-office workers who were exposed to short, intense fields from telephone switching machinery were more than three times as likely to get prostate cancer and more than twice as likely to get oral cancer as co-workers who were less exposed.[144]

These suggestive findings were supported by another study at the Hutchinson Cancer Research Institute in Seattle, which found a relationship with jobs that involved exposure to EMFs. Electricians, utility linemen, and power-plant workers – whose jobs involved the highest exposure to EMFs – had six times the risk of developing breast cancer as had men in occupations with no EMF exposure.[144]

Laboratory Studies

Strong electric fields can stimulate the skin of animals by vibrating hairs or by triggering various sensors in the skin. Low-frequency EMFs – such as those produced by the 60-hertz electric currents in power-distribution systems, may induce weak electric fields inside the body.[146]

Normal tissue growth is controlled by feedback involving hormones, such as growth hormone. Cells "communicate" with each other through structures in the cell membrane – including those called gap junctions – which provide electrical and chemical coupling between cells. A variety of experiments have shown that fields, even weak fields, can interact with the cell surface to produce changes in how the cell operates. For example, an enzyme present in all cells, ornithine decarboxylase (ODC) is essential to cell growth. ODC activity is another cellular process that can be affected by 60-hertz fields.

In another experiment, 60-hertz fields were found to change the rate of DNA synthesis in certain human cells. Under the influence of electrical fields, new proteins are formed, and the quantities of proteins are changed to produce shorter molecules. The nature of the change depends upon the frequency of the field.

For more than 15 years, orthopedic surgeons have used strong, pulsating magnetic fields to speed the healing of fractures, though no one really understood why fields triggered bone healing. A possible explanation is that parathyroid hormone stimulates the breakdown of bone and inhibits bone growth, and magnetic fields seem to block the action of this hormone.[146]

Chapter Seven
Emerging Issues

Many issues are emerging as potential health concerns as we try to cope with a rapidly evolving industrial society. Three of the most important of them are noise, waste management, and global warming.

Noise

Noise is unwanted, generally loud or harsh sound, and the degree to which we can tolerate it is relative. Our ears are remarkably sensitive to the waves of small but rapid oscillations, or changes, in air pressure that we know as sound. The frequencies of these range from 20 cycles per second to 20 000 cycles per second.

The strength of a sound is measured in terms of its sound pressure level (SPL). This is the extra acoustic pressure caused by sound over normal atmospheric pressure. All SPL is measured in decibels (dB). For example, a very painful and damaging noise has an SPL of 140 decibels (figure 28). The loudness attributed to a sound varies with its frequency (pitch), as well as its sound pressure level. A sound-level meter, a small microphone connected to special electronic circuitry, is used to measure SPL.

How We Hear

The ear consists of three distinct regions: outer, middle, and inner ear. When sound enters the ear, air waves pass along a canal to the eardrum. Each wave vibrates the eardrum, which conducts the sound to the ossicles, the three smallest bones in the body.

The ossicles transmit the vibrations to a fluid contained in a tiny snail-shaped structure called the cochlea. Microscopic nerve endings within the cochlea respond to fluid vibrations. Electric impulses from nerve endings are transmitted to the brain and interpreted as sound.

Major Sources

The primary reason why noise has once again become an important environmental pollutant is the growth of major noise sources, affecting more people.[148] A major noise source is defined as a level of sound high enough to annoy people, and to affect a significant proportion of the population. Major noise sources in Canada are: road and air traffic, construction, and industry; other forms of transportation, such as motorboats and trains; and people, for example, playing loud music.

Road traffic noise is easily the most pervasive noise in Canada. According to a national survey by Transport Canada, 19 percent of respondents complained that road-traffic noise was the most disliked feature in their neighbourhood. As might be expected, major sources of this annoyance are busy freeways, as well as excessively noisy cars, heavy trucks, and motorcycles.

Aircraft noise, while loudest and most objectionable during take-off and landing, is also most disturbing over the more densely populated parts of the country. Noise from industry, construction and demolition work is also of a very high level and a serious disturbance to people. Many municipalities restrict construction to between the hours of 7:00 a.m. and 7:00 p.m.

Noise from industry, construction and demolition work can be very loud and disturb people. Workers must wear equipment to protect their hearing.

Many of the noise sources from power tools, home appliances, subways, trains, and motorboats could cause hearing damage if a person were continually exposed for a long time. Fortunately, the number of people receiving such a high exposure is limited, with the possible exception of rock musicians and fans.[147]

Noise and Health

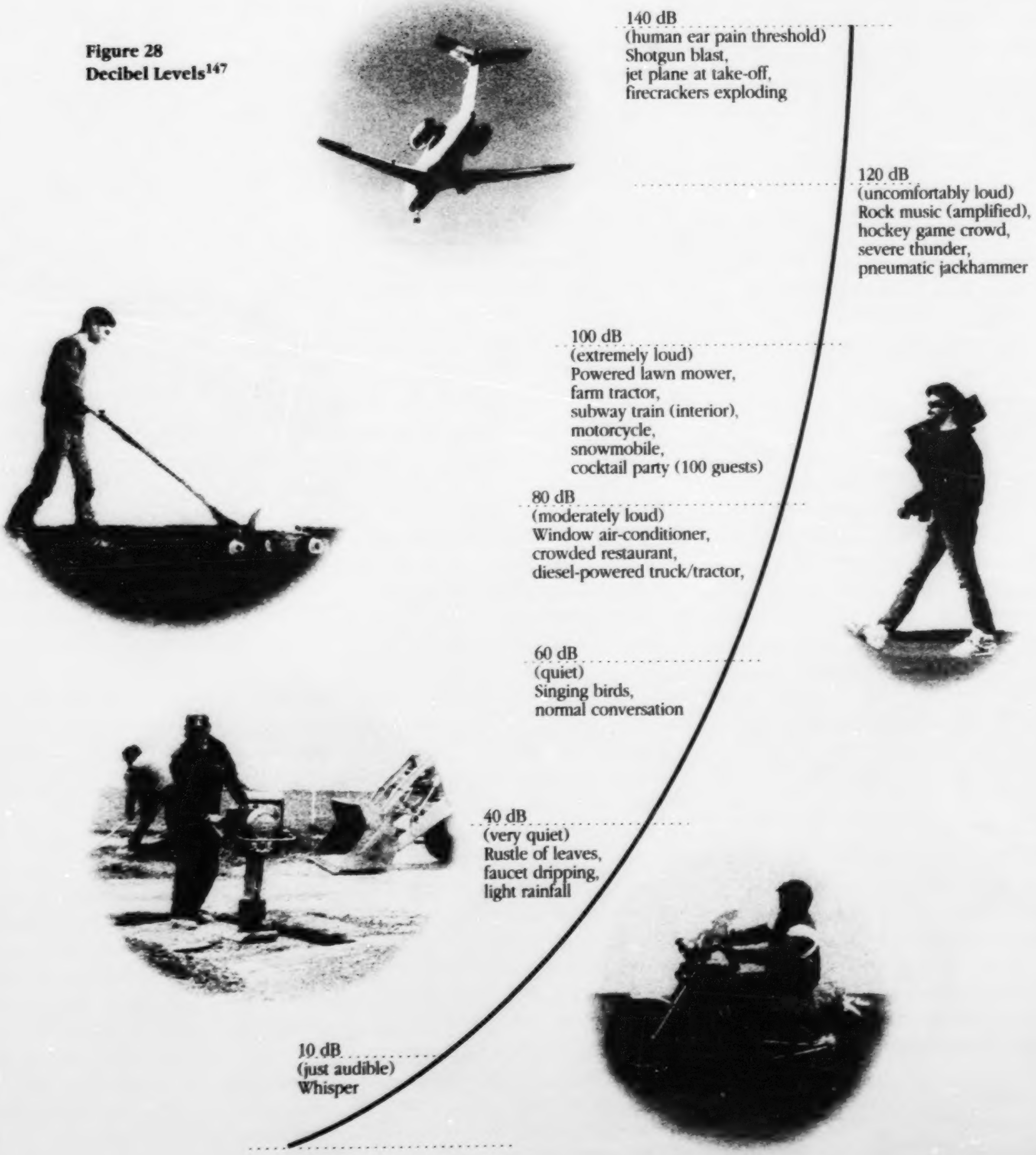
Excessive noise is harmful to the health and well-being of many people. One major effect is permanent hearing loss. However, even at exposures too low to cause permanent hearing loss, noise can significantly affect health and well-being by interfering with listening, startling people, disturbing sleep and rest, and causing severe annoyance and stress.[149, 147]

Hearing Loss

There is considerable variation in the effect of noise on an individual; some people are very susceptible to noise-induced hearing loss and some very resistant.

Hearing loss caused by noise results from overexposure to sound, which can cause direct physical damage to the hair cells of the inner ear.[150] There are two categories of hearing loss: temporary or permanent.[147]

Figure 28
Decibel Levels[147]


140 dB
(human ear pain threshold)
Shotgun blast,
jet plane at take-off,
firecrackers exploding
120 dB
(uncomfortably loud)
Rock music (amplified),
hockey game crowd,
severe thunder,
pneumatic jackhammer
100 dB
(extremely loud)
Powered lawn mower,
farm tractor,
subway train (interior),
motorcycle,
snowmobile,
cocktail party (100 guests)
80 dB
(moderately loud)
Window air-conditioner,
crowded restaurant,
diesel-powered truck/tractor,
60 dB
(quiet)
Singing birds,
normal conversation
40 dB
(very quiet)
Rustle of leaves,
faucet dripping,
light rainfall
10 dB
(just audible)
Whisper

A person who is exposed to a period of loud noises may have trouble hearing for some time (temporary hearing loss). Normal hearing usually returns after a rest period which may last from a few minutes to a few days, depending on the person, and how long and severe the exposure was.

Permanent hearing loss resulting from exposure to loud noises is usually very gradual. This cumulative effect depends on the total sound energy to which the ear is exposed, regardless of the cause of the noise.[151]

Present industrial noise standards do not protect every worker from developing hearing losses. For example, the 90-decibel limit on noise for a 40-hour weekly exposure in industrial settings results in about 10 to 20 percent of workers suffering hearing impairment solely due to noise exposure after 30 years.[150] There is evidence to support lowering the occupational noise limits, and recently Labour Canada lowered its occupational noise limit to 87 decibels.

Sleep

Certain segments of the population, such as the old, middle-aged, and sick, are particularly sensitive to sleep loss from noise.

Annoyance with noise can keep a person from falling asleep, and noise may awaken that person during the night. It may also disturb the cyclical pattern of sleep. These effects lead to a decrease in sleep quality which, in turn, can lead to increased tiredness and decreased performance the next day, with the possibility of more serious effects on health and well-being for long-term exposure.[149]

Annoyance and Stress

Excessive noise can cause severe annoyance and can result in stress. The effects of the annoyance alone significantly reduce the health and well-being of people in exposed communities. In addition, while studies are inconclusive, there are concerns that excessive noise can indirectly affect the cardiovascular system.[149]

Control

Noise from almost any source can be controlled. Noise-control measures should be directed primarily at reducing noise at the source, and secondarily at the receiver, or on the path of transmission between the source and receiver.[147]

Problems in controlling noise should be anticipated at the design stages of a new building or plant. It is usually good practice to have someone who knows about acoustics and noise control examine the design work of engineers and architects to ensure that noise problems are handled before they develop.

Special acoustical treatment of roofs and walls with double-layer construction helps cut down on noise. Equipment producing high levels of noise should be kept away from areas such as office or conference rooms. Noisy equipment

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A Study of Low-level Flights

Concern has been expressed that low-level flights, especially military flights in Northern Canada, are a source of noise pollution and can affect both the environment and human health. A review of the medical literature on the effects of noise produced by low-level flights concluded that mildly harmful effects on hearing could occur but that other effects were more significant. These included stress-related effects such as hypertension, as well as "startle" reactions such as ducking and flinching. Children appeared to be particularly sensitive to the effects of low-level flights.[152]

At the invitation of the Government of Newfoundland and Labrador, the Canadian Public Health Association formed a task force in 1985 to examine the health effects of increased flying over the Labrador area. Its report concluded that, on occasion, low-level flights could create noise at levels potentially damaging to hearing. However, because of the few flights in the area, the probability of hearing damage was very low. The task force recognized the emotional and mental health effects that low-level flights could have for Innu children and adults and recommended that low-level flights not be increased until environmental studies have been completed. It also recommended that studies be undertaken to measure the health benefits and liabilities of the traditional Innu lifestyle.[153]

should also be located at grade levels that minimize vibration and noise transmission to other areas of a building. Special enclosures and free-standing barriers are other methods to consider in overall noise control.[154]

Barriers and enclosures are an effective technique in reducing sound levels. For a barrier to be effective, it should be high enough to intercept the line of sight from the source to the receiver. Free-standing noise barriers require a minimum of space, allow easy maintenance, and physically separate a person from the noise source. The surface features of a region, such as hills or ravines, can be exploited to act as natural barriers.

Generally, it is less expensive to buy quiet equipment than it is to silence noisy equipment. Most manufacturers can provide sound-level data for equipment, which can then be modified to reduce sound.

Mufflers can control low-frequency noise. Mid- to high-frequency noise in ducts and openings can be controlled by lining the walls with sound-absorbing material.

Devices to protect personal hearing are physical barriers that reduce the amount of sound energy transmitted to receptors in the inner ear. These devices are either inserted to plug the external ear canal, or cover the ear like earmuffs to seal it from unwanted sound.[147]

One of the main concerns with landfills is the possible contamination of ground water from chemicals leaching from the sites.

Classifying and labelling equipment in terms of noise emission is another way to reduce noise. The difficulties lie in establishing a uniform system of noise classification across Canada that does not conflict with international trade barriers.[147, 154] The system should also promote techniques for reducing noise economically and, perhaps most important, ensuring that purchasers of labelled equipment appreciate the full benefits of purchasing quieter devices.

Waste Management

Waste management has become a major issue in Canada. Canadian consumers and industry are more conscious of the need to generate less waste, and are modifying their habits accordingly. They are beginning to employ the four Rs: Reduce, Reuse, Recycle and Recover, in that order of importance. Economic viability, markets for recycled goods, energy costs, program administration and public support all play key roles in the success of each of these strategies.

In spite of our best efforts to reduce the amount of waste for disposal, some will always remain. We must properly transport, handle and dispose of waste so that we can avoid damage to the environment and protect human health.

Cleaning Up Contaminated Sites

A program to assess and clean up contaminated sites in Canada was introduced in 1989. The National Contaminated Site Remediation Program (NCSRP) is a federal-provincial program created under the auspices of the Canadian Council of Ministers of the Environment (CCME). It is administered by Environment Canada and deals with contaminated sites that are either under federal jurisdiction or are "orphaned," with no jurisdiction claiming responsibility. The program also promotes the development and demonstration of technologies that could be used to help in those clean-ups.

Health and Welfare Canada is responsible for assessing the human health risks posed by contaminated sites, developing scientific methods by which human exposure and risk are measured, and establishing clean-up guidelines for contaminants. These guidelines, based on health needs, will help to define the extent to which a site is cleaned up so that it no longer presents a health hazard. In addition, the various clean-up technologies will be assessed to ensure that they do not inadvertently lead to new health hazards or create problems greater than those they were meant to solve.

More than 10 000 waste disposal sites have been identified in Canada, and about 1 000 of these are of high concern. These areas include hazardous-waste disposal sites, municipal-waste disposal sites, contaminated industrial sites and locations where chemical spills have occurred.

A number of projects are under way or are being planned to help identify and reduce the health risks of these sites. These include:

- studies of people living near the sites (epidemiological investigations);
- approaches to risk assessment;
- bioavailability of chemicals and estimates of exposure;
- assessment of clean-up technologies;
- estimation of the general public's exposure to contaminants, and comparison with that of people living near contaminated sites;
- development of standards for soil quality guidelines; and
- establishment (jointly with Environment Canada) of a national data base of concentrations of contaminants in water, soil, sediment, air, fish, and wildlife.

A national framework for assessing the risks posed by contaminated sites is being developed. It will be considered by technical personnel from the provinces and territories, industry, public health associations and other people interested in this subject.

Waste can be defined as any substance or mixture that is discarded because it has no apparent value. In Canada, an estimated 30 million tonnes of waste are produced annually (1988 figures), of which an estimated eight million tonnes are considered hazardous.

Wastes can be either natural or manufactured. The human activities that generate wastes are as diverse as the substances themselves. Waste can come from households, institutions, agriculture, medical and laboratory facilities, industry, or municipalities. Industrial, municipal and biomedical wastes are further classified into hazardous or non-hazardous waste.

Disposing of Hazardous Wastes

Hazardous waste has some or all of the following properties: toxicity; the potential to cause disease; the potential to explode or react unexpectedly; corrosiveness; flammability and oxidizing potential or both; and environmental persistence. The nature or quantity of wastes may render them potentially hazardous to human health and may allow them to persist in the environment for many years. They require special destruction, treatment, and disposal processes to minimize or eliminate the potential hazard.

One important aspect of waste management is how to resolve the issues of risk to human health and the environment of each of the disposal options: landfilling, incinerating, and storing.

Landfilling

Hundreds of years ago, landfilling was akin to modern composting. It is still the most common waste-management technique in Canada, simply because of its low immediate costs.

The Canadian landscape is dotted with more than 10 000 active, closed, or abandoned waste sites, including sites containing municipal and biomedical wastes, hazardous substances and pesticide containers. The siting of these landfills can result in the contamination of ground water.[155, 156] This causes significant concern since approximately 25 percent of the Canadian population rely on ground water as a source of drinking water.[157, 158] Because ground water around disposal sites may not be monitored sufficiently, the seriousness and extent of leaching from landfills is still relatively unknown.[159]

Many of the problems encountered so far stem from the unregulated disposal of wastes in unlined or open pits and ponds. This facilitates leaching from these wastes and the resulting entry of toxic materials into ground and surface water, and eventually into the food chain. Landfill gases, such as methane and carbon dioxide, are also of concern since they are greenhouse gases associated with climate change. However, these gases sometimes migrate into nearby homes and can, on occasion, result in explosions. Modern landfills are vented to release these gases.

The assessment of waste sites normally involves evaluating potential health risks. Canadians potentially most at risk are those working or living near disposal sites as well as firefighters, police and disposal experts who may have to enter the sites in an emergency.

There are no epidemiological studies involving people living near disposal sites for hazardous wastes in Canada. Unfortunately, many of the studies done in the United States have been inconclusive. Nevertheless, there are health concerns associated with the substances contained in, and escaping from, many of these sites – including concerns about cancer and reproductive abnormalities.[155, 156]

In order to determine our exposure to toxic substances, researchers must measure and identify the contaminants at the site. The researchers must also determine the migration patterns of those substances or mixtures, and what happens to them in the environment. As well, the researchers must consider the current and proposed use of the site and surrounding lands as well as the proximity to and population density of the affected area.

Researchers measure the potential human exposure by the amount of contaminated food or water that people eat and drink, and the degree to which it is contaminated (see also Chapter Two). They also consider the possibility that contaminants could be absorbed through the skin or inhaled in contaminated dust and vapour. The degree of hazard to humans posed by the site can also be influenced by such factors as whether access to the site is restricted, the number of people living on or near the site, the amount of ground water that is used for drinking, and the degree of contamination from the surrounding and underlying land.

Health and Welfare Canada is compiling toxicological information on baseline chemicals in air, water and soil to help the Department assess health risks to people living near orphaned and federal waste sites.

Incineration

As the immediate cost of landfills increases, and as more information about the adverse effects of landfilling on human health and the environment emerges, incineration may become a more attractive option.

If incineration is effective, it chemically alters hazardous waste, reducing its volume by an average of 90 percent and, in most cases, its toxicity as well. The process is particularly suited to destroying PCBs, dioxins, furans and other chlorinated organics, because it can destroy the chemicals without producing significant quantities of toxic by-products, thereby eliminating the need for storage and reducing health risks.[103] Both industrial and municipal waste incinerators, if improperly operated, produce ash that may contain heavy metals such as arsenic, cadmium, mercury, lead, and nickel. The health effects of these metals are described in Chapters Two and Three.

There are a number of possible ways that incineration systems can themselves produce environmental contaminants: ash residue; wastewater effluent and waste sludges from water treatment; and gas from exhaust stacks. All of these ways result in some level of human exposure and therefore increase the risk to health. However, the most significant health concern is the emission of contaminants by gas from exhaust stacks.

Storage

Reluctance to dispose of waste often leads to what is the least desirable of all waste-management options. Long-term storage entails some risk of environmental release, such as the fire at the PCB warehouse in Saint-Basile-le-Grand, Quebec. A release of contaminants in such a way could potentially result in a variety of adverse health effects ranging from the minor to the severe.

Types of Waste

The following types of waste have important implications for waste management.

Municipal Solid Waste

Canadians are among the largest producers of municipal solid waste (MSW) per capita in the world.[160] Crude figures indicate that only 10 percent of waste is recycled, 5 percent is used to reclaim energy and 3 percent is incinerated, while 82 percent is deposited in landfill sites.[161] As current landfills quickly fill up, locating acceptable sites has become an environmentally, socially and politically contentious issue.

Sewage Sludge

Sewage sludge is another form of waste. It is estimated that each person produces half a cubic metre per year of stabilized sewage sludge containing traces of cadmium, mercury and PCBs, mainly from industrial effluents. Sewage treatment plants are estimated to produce 90 grams of dry sludge daily per person. The practice of distributing sludge over agricultural land has become less frequent since increases in the metal content of soil have been observed, and because of the risk associated with disease-causing micro-organisms. Another alternative is incineration although it, too, may release toxic metals into the atmosphere.[162]

Canadian consumers play a critical role in creating and dealing with hazardous waste. The average household has a number of hazardous products, including solvents, cleaning products and paints, that require careful disposal.

A Health Study of Sewage Sludge Workers

A health study of sewage workers at a Toronto sewage treatment plant was carried out in 1985 to investigate whether there were measurable health effects in a plant that processes PCB-contaminated sewage and sludge.[163] The study was designed to show whether the PCB concentration was higher in the blood of these workers and whether they had any evidence of illness that could be attributed to their work.

A pilot study was done of 50 workers selected randomly out of a total of 332. The investigators noted that many workers reported "influenza-like" symptoms, cough, sputum, wheezing, sore throat, and skin complaints. The lung function of the sewage workers tended to be lower than expected. PCB concentrations in blood were not significantly higher than normal levels in unexposed groups and did not suggest that the workers had been exposed to high levels of PCBs. There were no adverse health findings that could be related to PCBs.

Special emphasis was placed on the possible effects of people working in the area of the plant where heat treatment dried the sludge before disposal. The workers believed that there was a greater amount of illness after this process began. Indeed, there were more reported 'flu-like symptoms, and cough and throat irritation in the workers in this area.

The reasons for the health effects demonstrated in the study were not established and further investigation was suggested. On the basis of this study, it was not possible to make specific recommendations to better protect the sewage workers. The study did raise the possibility of an association between fly ash – dust from the sludge incineration process – and respiratory impairment.[163]

Biomedical Waste

In recent years the disposal of biomedical wastes from hospitals, laboratories, and other research facilities has come under critical public scrutiny. Public attention was drawn to the problem when medical wastes washed up on some public beaches, and discarded needles were found in dumpsters. The awareness of AIDs contributed to this concern.

The management of biomedical waste is receiving greater attention now that people have gained a greater appreciation of the potential risks of improper disposal, as well as of the liability associated with mismanaging infectious wastes. The costs of treatment and disposal of waste compound the problem, because of the difficulty in locating suitable disposal facilities.[164]

A recent U.S. survey indicated that hospitals generated an average 6.93 kilograms of hospital waste per patient per day.[164] Hospital waste refers to all solid waste – both biological and nonbiological – that is not intended for further use. Medical waste is defined as materials produced as a result of patient diagnosis, treatment, or immunization, such as dressings and intravenous tubing. Infectious wastes refers to the portion of medical waste that could transmit an infectious disease. It may include: cultures and stocks of infectious agents and associated biological materials; human blood and blood products; pathological waste; contaminated "sharps" such as broken glass or needles; animal carcasses; body parts; waste from body parts and bedding; and wastes from patients in isolation.[165] Health care professionals are concerned about proper management of biomedical wastes, because certain wastes have been associated with transmitting infection and causing injury.[164]

Hospitals usually have a written policy that not only defines the categories of wastes, but also specifies that infectious waste must be segregated from other waste by labelling, colour coding, using puncture-proof containers, and disposing of them by different means.[166]

Infectious wastes are generally incinerated or steam sterilized prior to disposal, whereas hospital wastes that are not infectious are discarded directly into a sanitary landfill.[164] Critics believe that incineration is a more effective method of disposal; it not only reduces disposal expenses, but also provides heat.

Incineration also easily sterilizes pathogens, and can handle animal carcasses and hazardous chemicals. Incineration reduces land requirements for disposal by eliminating most of the original volume of the waste.[164]

Household Garbage

Canadian consumers play a critical role in creating hazardous waste. Individual households produce a relatively small percentage of hazardous waste, but collectively the amount is significant, and the number of households continues to grow.

Common types of hazardous garbage from homes include art supplies, batteries, pesticides, cleaning products, paints and solvents, pharmaceutical supplies, pool chemicals, propane cylinders, used crankcase oil, and wood preservatives. Such garbage poses two kinds of problems: disposal, and use.

Many home-owners put hazardous wastes out for garbage collection, or pour them directly down the drain. Often the sewage-treatment processes cannot treat them effectively, so they can end up in our drinking water, or in lakes and rivers.

Some household cleaners can cause serious health effects if they are used improperly and are consequently swallowed, inhaled, or exposed to skin. Particularly in a home with small children, such chemical products can lead to a potentially unsafe environment.

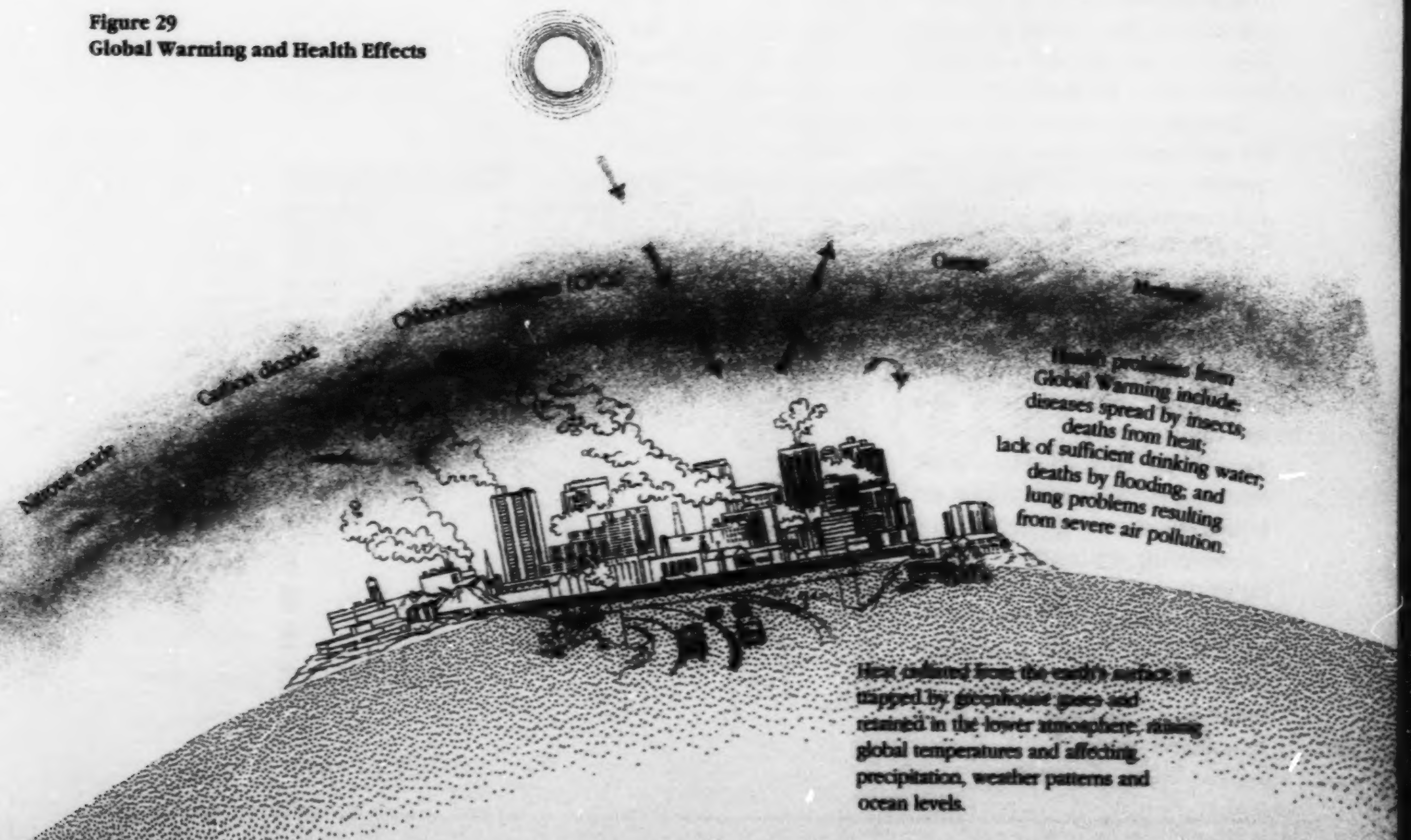
Global Warming and Climate Change

Human activity has resulted in significant changes to the atmosphere. Most of these changes are usually visible near the source of the pollution but some subtle changes are occurring throughout the world that could have profound effects on the ecosystem and human health. One example of this is the change in the average temperature of the earth. This results from the increase in so-called "greenhouse" gases. Gases such as carbon dioxide, methane, ground-level ozone, nitrous oxide and CFCs build up in such concentrations that they interfere with the earth's normal balanced process of releasing heat into space.[167] This process mimics a greenhouse by allowing light energy to be absorbed by the earth, while trapping heat close to the surface. The result is an overall warming effect.

Some of the greenhouse gases are present in the atmosphere in greater amounts than others, and some absorb more heat than others. For example, while carbon dioxide is the principal greenhouse gas, a CFC molecule has 10 000 to 20 000 times the warming impact of a molecule of carbon dioxide.[97, 75] The relative contributions made by the various gases to global warming are: carbon dioxide, 49 percent; methane, 18 percent; CFC-11 and CFC-12, 14 percent; nitrous oxide, 6 percent; and other gases, 13 percent.[168]

It is important to point out that we do not fully understand all the factors that contribute to global warming and climate change. Nor do we know with certainty what the ecological and health implications will be of climate change. Some scientists predict that the average annual temperature of the world may increase as much as 5°C over the next 50 years. This may not seem like much considering that some people have been through temperature fluctuations of 30°C in a day without catastrophe. However, a 5°C average increase over the entire planet means that some geographical areas may have extreme changes over short periods

Figure 29
Global Warming and Health Effects



Health problems from Global Warming include: diseases spread by insects; deaths from heat; lack of sufficient drinking water; deaths by flooding; and lung problems resulting from severe air pollution.

Heat radiated from the earth's surface is trapped by greenhouse gases and retained in the lower atmosphere, raising global temperatures and affecting precipitation, weather patterns and ocean levels.

of time. These areas may experience some of the most severe effects, although it may be another decade before scientists can make more accurate predictions, especially for changes at the regional level.

By anticipating some of the likely climate changes that might occur from global warming, it is possible to speculate on what might be some of the health impacts (figure 29). For example, global warming may increase the frequency and severity of heat waves, causing illness and possibly death. The elderly, the sick, and people who are not acclimatized to extremes in temperature would be particularly affected.

Disease patterns may also change. Diseases that are transmitted by organisms such as mosquitoes or ticks – such as malaria and Rocky Mountain Spotted Fever – may move into new areas as the insects seek a climate in which they can survive. Thus, areas previously free of certain diseases may become a haven for them.

Changes in precipitation and runoff may occur. In some areas, the quantity of water may be reduced and the quality of drinking water may be affected, especially since there would be less water to dilute pollution.

Pollution in the atmosphere can, in turn, be affected by changes in temperature, humidity, wind speed and direction, precipitation, and weather patterns. Increases in air temperature and in ultraviolet radiation levels due to the depletion of ozone in the stratosphere would indirectly lead to more ground-level ozone, particularly in cities. Reductions in lung function have been documented and are thought to result from damage to lung tissue by inhaled ozone.[169]

Changes in local weather patterns, which influence factors such as soil moisture, may affect agricultural production in many areas. Some areas that now are not fit for growing crops or are only of marginal use may become productive. Other areas that are now critical in supplying food may gradually turn into deserts. This has obvious implications for human nutrition and health. Developed nations are unlikely to be severely affected by such changes because they have the means for effective food distribution. However, people living in developing nations will be more susceptible to food shortages or changes in local agricultural production.

Global warming may also cause sea levels to rise, flooding many coastal areas. There may be more frequent and severe storms. Such catastrophic events could, in some nations, lead to mass human migrations to more livable places. These migrations would in themselves pose health risks, since people would have to cope with unclean conditions, minimal supplies of food and clean water, and the threat of disease epidemics.

Although Canada will probably experience some of the effects of global climate change, the impact will likely be more severe in developing nations that lack economic and medical resources to deal with it effectively.

Chapter Eight
Protecting the Health of Canadians

Canadians are among the world's healthiest people, but constant effort is needed to keep ourselves and our environment healthy. One of Health and Welfare Canada's main concerns is to protect Canadians from possible health hazards posed by environmental contaminants.

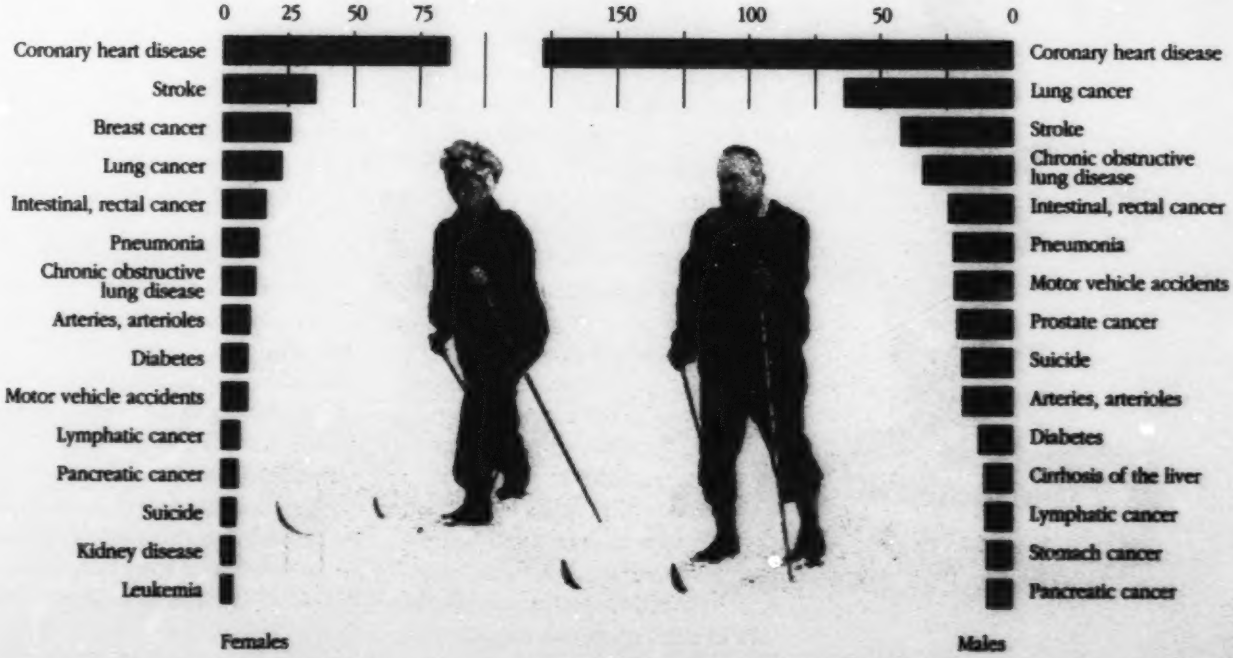
Protecting health is a complex procedure that includes identifying health hazards, estimating the level of risk they pose, and developing options to deal with them. The Department has formalized all of these steps in a process known as "risk determination," which forms the basis for its health protection strategy (figure 31).

The Health of Canadians

Because of a high standard of living and a good environment, Canadians are among the healthiest people in the world. Although the life expectancy of Canadians is steadily increasing, eventually everyone has to die from something. Not all major causes of death have close links with the environment, but some do. In particular, certain types of cancer are known to be partially linked to environmental factors.[170]

Some of the major causes of death are given in figure 30. However, lifestyle choices such as diet and smoking, along with genetic influences, are contributing factors in causes of death.

Figure 30
Major Causes of Death in Canada[170]
(standardized mortality rates, 1989)
Deaths per 100 000



Determining Risks

Life is full of risks. We, as individuals, must make many of our own choices about the risks we face in our day-to-day activities. Personal choices related to risk include simple things like looking both ways before crossing the street as well as more complex decisions like driving a car or engaging in high-risk sports such as rock climbing. The British Medical Association[172] has developed a ranking of various risks (see figure 32). While this ranking is more relevant to the people of Great Britain than to Canadians, it shows that we are all exposed to a variety of hazards every day, with a tremendous range in the degree of risk.

We also make lifestyle decisions about where we live, what we eat and drink, and whether or not to smoke. However, while each person can choose to avoid or reduce many health risks from the environment, the individual cannot cope with all of them. The government must monitor some problem areas.

In order to find a balance that will best protect the health of Canadians, Health and Welfare Canada must consider and weigh significant environmental risks in a scientific manner. The Department's basic approach to determining risk

Figure 31
Steps in Assessing and Managing Health Risks[171]

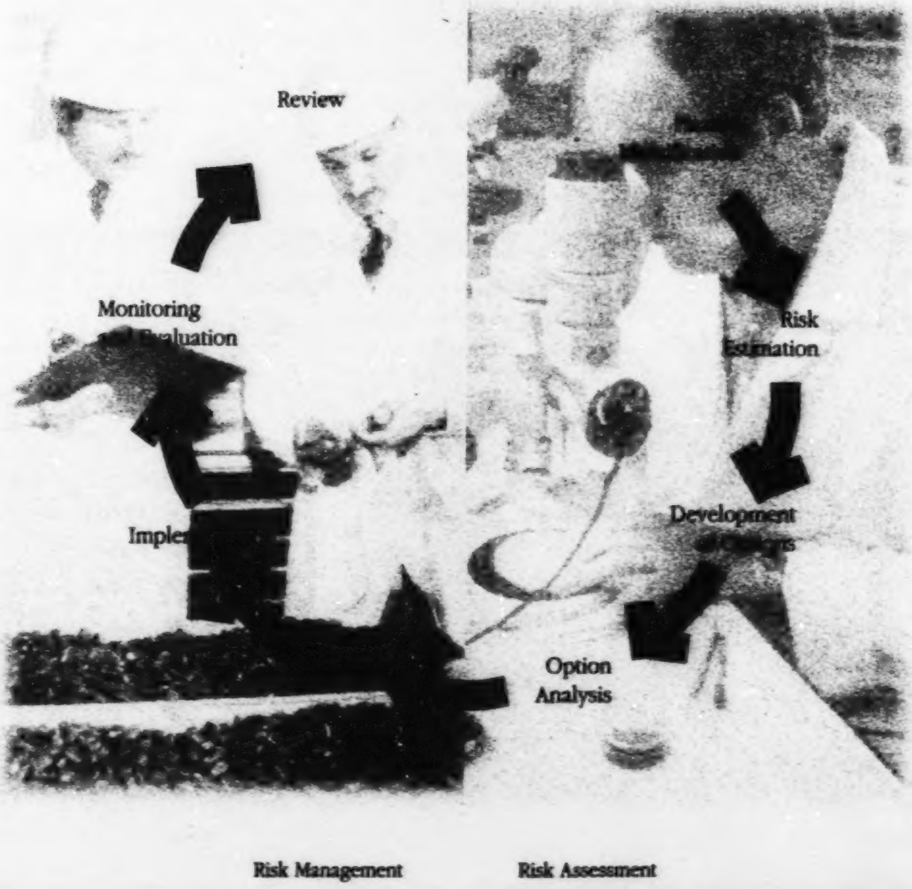
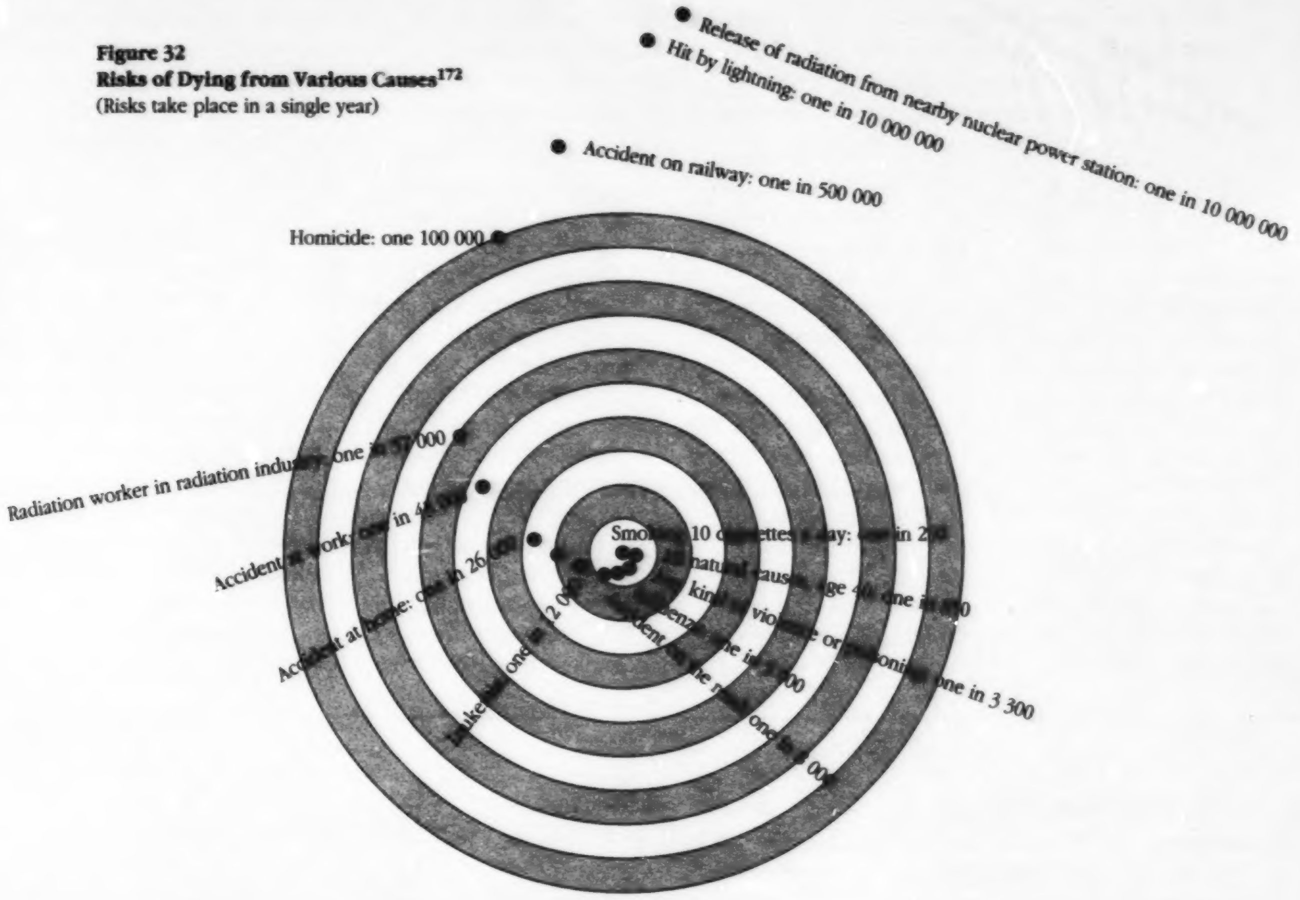


Figure 32
Risks of Dying from Various Causes[172]
(Risks take place in a single year)



consists of several steps to assess environmental health risks and "manage" them. The latter steps in this process involve making, implementing, monitoring and reviewing decisions taken in response to identified environmental hazards.[171]

Identifying Hazards

The first step scientists take in assessing risks is to confirm that a health hazard exists. Scientists use a variety of approaches to investigate the potential effects of environmental contaminants on human health. The two main sources of information are epidemiological studies of human populations and toxicological tests conducted in research laboratories.

Epidemiology

The field of epidemiology originally focused on outbreaks of communicable diseases. Indeed, the study of modern disease patterns in people began during an outbreak of cholera in London, England, around 1840. A physician, Dr. John Snow, tried to find a common element in the case histories of cholera victims he treated. He soon learned that they all used a particular public water pump, so he simply removed the pump handle to prevent the disease from spreading.

Today, any occurrence of a number of specified communicable or chronic diseases is reported to municipal, provincial or territorial health authorities. In this way, epidemiologists can keep track of the

Epidemiological Investigations Related to Tritium Releases

In 1991, Health and Welfare Canada responded to allegations that birth defects and infant mortality in the township of Pickering and city of Ajax were related to tritium released from the Pickering Nuclear Generating Station.(3) The study, funded by the Atomic Energy Control Board, spanned the years 1973 to 1988, and covered an area within a radius of approximately 25 kilometres of the station.

It had two objectives: to ascertain whether the incidence of still births, infant deaths or birth defects was higher than expected; and to investigate whether there was any association between their occurrence and monthly emissions of tritium, a radioactive form of hydrogen.

The results of the study showed that the rates of still birth, neonatal mortality and infant mortality in the Pickering area were not significantly higher than rates in the rest of the province. Similarly the rates of birth defects – including central nervous system defects, congenital heart defects, and others – were not higher than expected in the area around Pickering.

The original allegations linked the birth defects with data on tritium released from the station. The Health and Welfare study evaluated them in connection with measurements of tritium made at ground level in the populated areas around the station. Such measurements of tritium have been made by the Department since 1972. No relationship was found between still births, infant deaths or birth defects and the levels of tritium in the cities being studied.

The researchers noted an increased incidence of Down's syndrome in Pickering and Ajax. A survey of the province of Ontario found a similar rate in the county of Leeds-Grenville. Other birth defects also showed increases in only one or two counties. There was no consistent relationship between the occurrence of Down's syndrome and tritium levels in Pickering and Ajax.

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circumstances surrounding each and every case of such a disease.

Historically, epidemiology has most often been used to investigate the cause of infectious diseases. More recently, however, it has been applied to study diseases caused by chemicals and other environmental factors. For example, researchers might record occurrences of bronchial asthma, a chronic condition severely affecting a person's breathing. These observations could be checked against information about levels of air pollutants to see whether there are links between asthma and air quality.

Epidemiologists use different approaches to study health and the environment.

Descriptive epidemiology uses health data that already exist, such as Statistics Canada's data on cancer, birth and death rates. These data are used to identify trends in health status, and to compare trends among different population subgroups. Such studies often lead to a specific hypothesis, or assumption, about the links between health and the environment that can be evaluated in later studies.

Analytic epidemiology is used to try to establish an association between a disease and its possible cause. There are different ways of doing this. One way might be to begin with the disease and try to discover a cause, for example, by comparing a group of lung-cancer patients and a group of healthy people with respect to their histories of cigarette smoking. Another way might be to start with a possible cause for the disease, and look for the effect. For example, a group of asbestos miners and a group of people not exposed to asbestos might be monitored over time for the occurrence of lung cancer.

Researchers are also interested in the clinical observations of doctors treating patients suffering from diseases attributable to the environment. Combining clinical and epidemiological information helps to narrow possible causes of specific diseases.

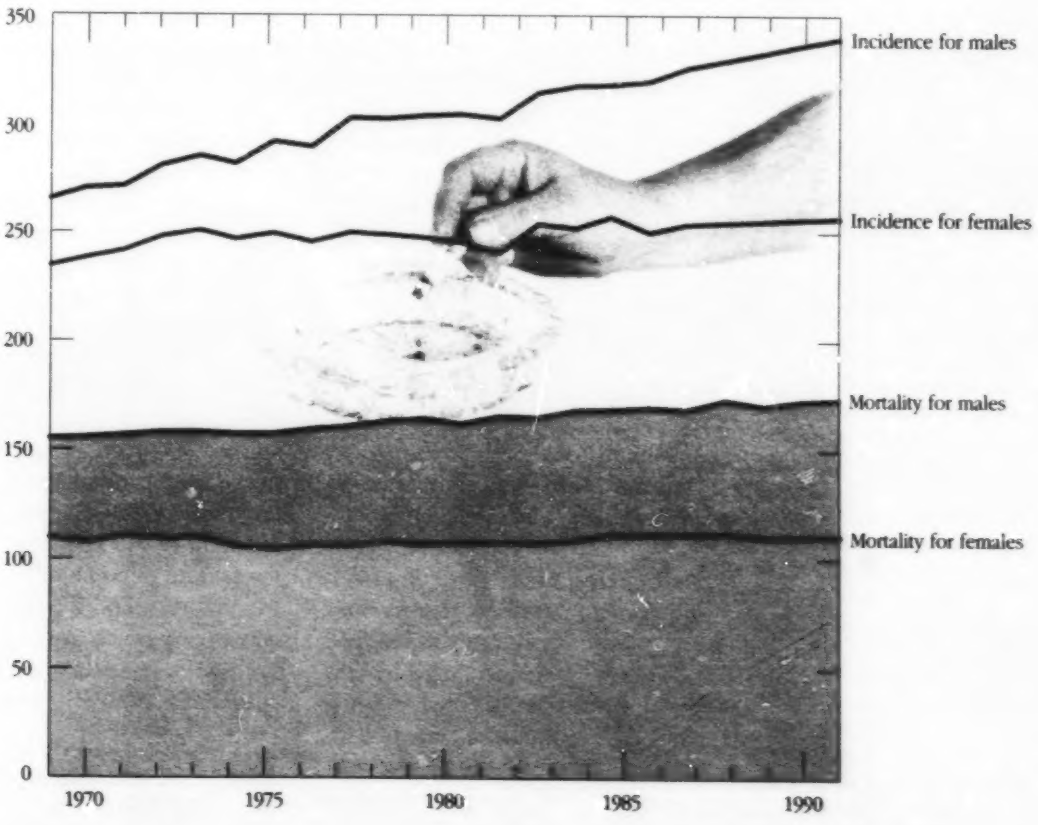
Some types of cancer are linked to known environmental, occupational and lifestyle factors, for example: bladder cancer – cigarette smoking and some organic chemicals; melanoma of the skin – sunlight; lung cancer – cigarette smoking and some inhaled chemicals, fibres or dusts.[174]

Figure 33 shows that the incidence (number of new cases) of cancer in men is increasing, as well as the mortality rate (deaths). For women the increase is less than for men. However, women have had more than a threefold increase in the death rate from lung cancer between 1970 and 1990. This is attributed to the increase in tobacco smoking among women.

Toxicology

Toxicology is the study of the adverse effects of chemicals on living things. Of course, not all chemicals are harmful in low doses; they may even be essential. Nevertheless it is possible for almost any substance, including distilled water, to be toxic if a person is subjected to a sufficiently high dose. The sixteenth-century scientist Paracelsus noted that "all substances are poisons;

Figure 33
Age-Standardized Incidence and Mortality Rates for All Cancers, Canada[174]
(rate per 100 000 population)



Rates are adjusted to the age distribution of the world population. All figures exclude non-melanoma skin cancer, and incidence rates prior to 1982 have been adjusted for under-registration in one province. Incidence of cancers from 1987–1991, and mortality *(deaths)* from cancers from 1990–1991, are estimates.

Toxicologists conduct a wide variety of laboratory tests to determine if a particular substance may present a risk to human health. Biochemical tests and tests based on cell cultures are increasingly being used in place of animal studies.

there is none which is not a poison. The right dose differentiates a poison and a remedy."

Toxicologists may conduct a wide variety of laboratory tests to determine if a particular agent may present a risk to human health. Indications of potential human health risk may be derived from studies of the effects of exposing laboratory animals such as rats or mice to the agent in question. Increasingly, toxicologists are using biochemical tests or tests based on cell cultures. These tests are performed in test tubes or Petri dishes, and reduce the need for animal testing.

By conducting studies within a controlled laboratory environment, the toxicologist is able to isolate the effects of the individual chemical agent. Interactions between different agents can be studied by administering them alone and in combination. Although toxicological studies afford a degree of precision that is generally not possible in observational studies of human populations, it is achieved by making comparisons of laboratory test conditions with the more complex human environment. Together, toxicological and epidemiological investigations provide important complementary sources of information on environmental health hazards.

Estimating Risks

Epidemiologists often express their estimates of health risk in the form of "disease incidence," that is, how often the disease is noted in a population. The *incidence rate* of a disease represents the chance that individuals will contract a particular disease over a specified time.

The incidence rate is usually expressed as a certain number of cases per a specified number of people, as in "six cases per 10 000 population." Using this rate as a starting point, epidemiologists can calculate two different mathematical measures of risk: "relative risk" and "population attributable" risk.

Relative risk compares the incidence rates of a particular disease in a population that has been divided into two groups: a group that has been exposed to a particular health hazard, and a group that has not been exposed. The risk is expressed as the factor by which the incidence rate increases in the exposed population group. For example, the relative risk of a smoker developing lung cancer is between 10 and 15 times that of a non-smoker.

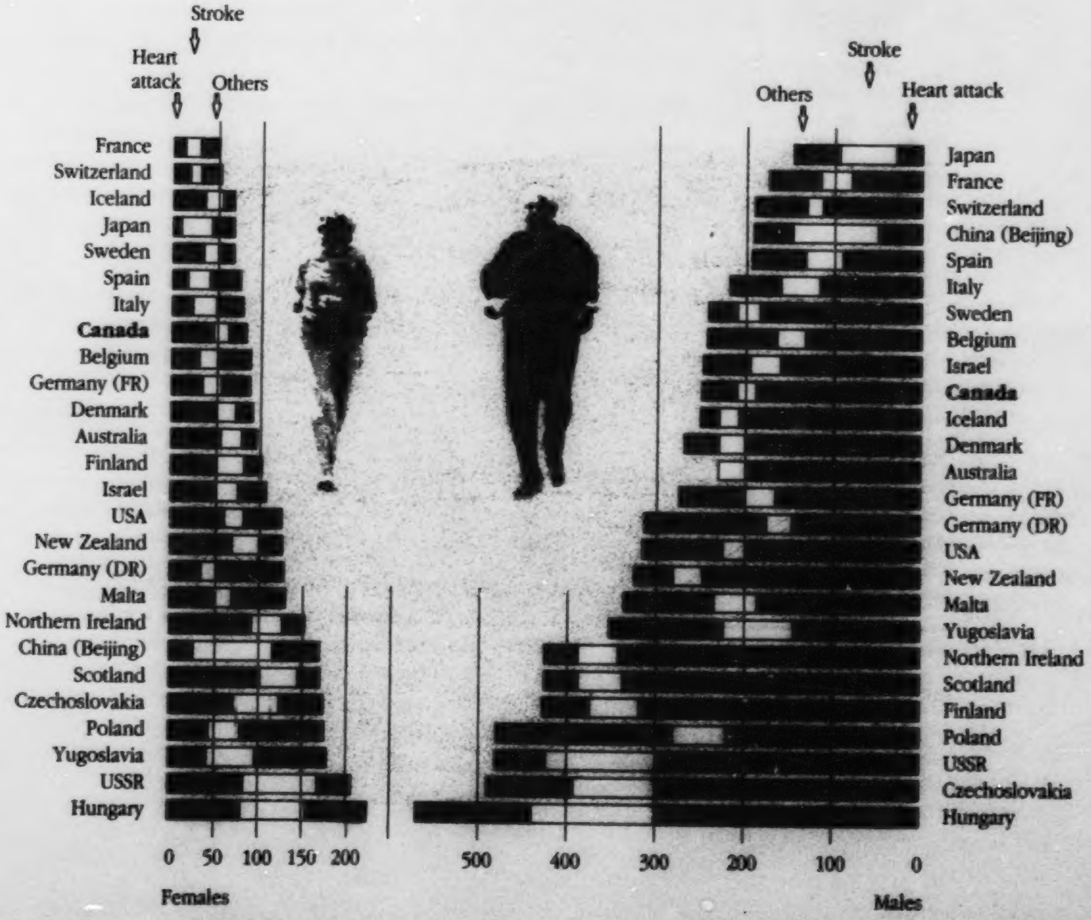
Population attributable risk represents the percentage of all disease cases that can be attributed to a specific environmental agent. An estimate of the population attributable risk can be obtained from the disease incidence rate and the percentage of the population exposed. For example, about 30 per cent of all coronary heart disease is attributable to smoking.

Figure 34 provides a comparison of the death rate due to heart and vascular diseases for people in several countries of the world. Included are deaths caused by heart attacks, stroke (burst blood vessels in the brain) and all other heart and blood vessel diseases. Canada is one of the 10 countries with the lowest rate of combined cardiovascular diseases. It is clear that females are much less susceptible to these diseases than males in all countries.

A primary objective of *toxicologists* is to determine levels of exposure to environmental contaminants that will present little or no risk to human populations. For many adverse health effects observed in laboratory studies (figure 35), this is done by finding a level of exposure at which no such adverse effects are apparent. This is called the No-Observed-Adverse-Effect-Level, or NOAEL.

Regulatory scientists often divide the NOAEL by an uncertainty or safety factor to establish an acceptable level of exposure for humans. The safety factor takes into account possible differences in sensitivity between animals and humans, and allows for variation in sensitivity among individuals in the human population. The magnitude of the safety factor may range from less than a hundredfold to more than a thousandfold, depending on the nature of the adverse health effects involved and the quality of the available toxicological data.

Figure 34
International Comparison of Mortality Rates from Heart and Vascular Diseases[175]



A different approach is required with certain delayed irreversible toxic effects such as mutation and cancer. This is because there may be no level of exposure to certain mutagens or carcinogens that does not present risk. In this case, zero risk can be achieved only by eliminating all possible routes of human exposure. Since this is not possible with naturally occurring carcinogens that may be widespread in the environment, guidelines for such substances are designed to reduce exposure and thereby limit lifetime cancer risks to as low a level as possible.

Developing Options

Once a risk has been assessed, there may be several ways of coping with it. The risk management options that Health and Welfare Canada can include are: making regulations, giving advice to other government bodies, recommending economic measures to reduce environmental pollution, setting voluntary standards for manufacturers, and providing information to the public.

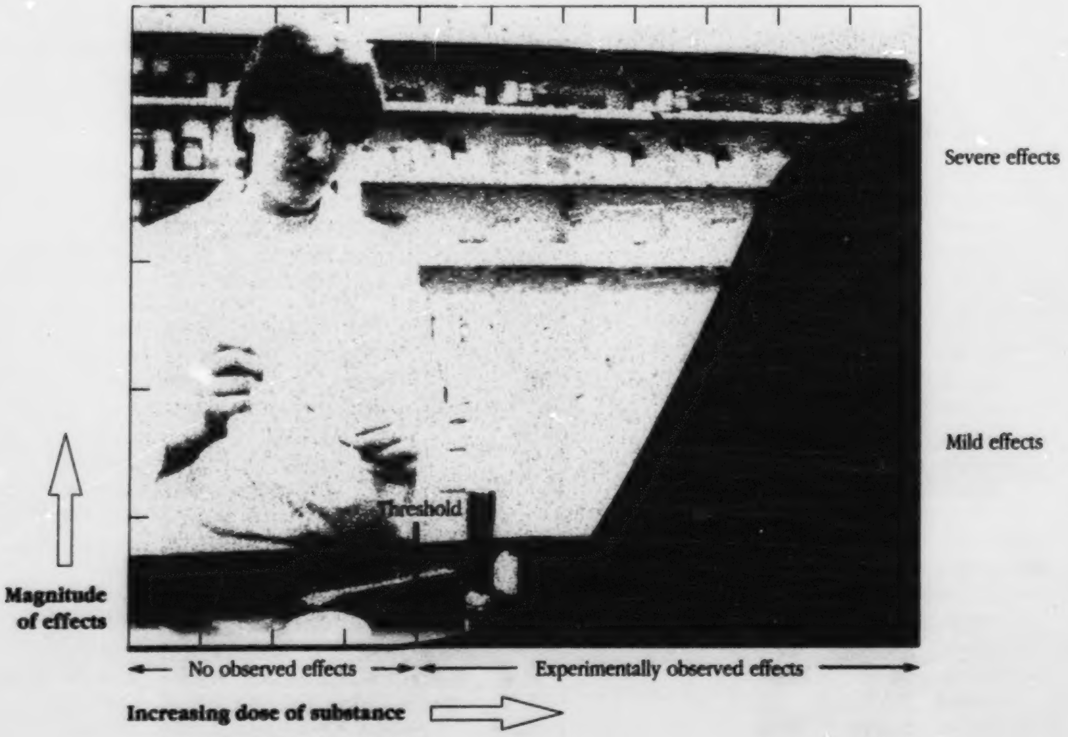
Analyzing Options

In analyzing each option, a number of questions are considered:

- How effective is each option at reducing or preventing the risk?
- What resources are needed to implement the option?
- What are the economic and social implications of reducing risks?
- Will a decision taken today set an acceptable precedent for similar situations in the future?

Considering these and other issues provides a basis for evaluating alternative strategies for risk management.

Figure 35
Dose-Response Relationship



Public Perception

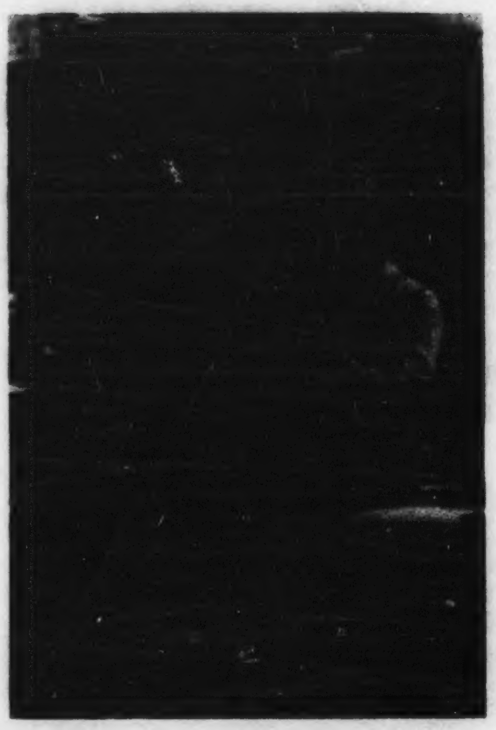
Decisions about how to deal with an environmental risk to health must also include the public's perception of the risk. The way people perceive risks is often subjective and intuitive; they frequently view risks in a way that differs from scientific assessments.

A 1984 study conducted by Decima Research indicated that the perception of risk depends on how often the public has heard about a hazard. That is, people perceived the hazards they heard about most often as more risky than others that were discussed less frequently.

A 1979 study found that Canadians viewed food additives, pesticides, and bacterial contamination in the food supply to be of about equal concern. This view contrasted remarkably with the scientific one that bacterial contamination is the single most serious threat to human health posed by the food supply.

Making a Decision and Implementing It

Ultimately a decision has to be taken on how to deal with specific environmental health issues. However, risk management does not end once a decision has been taken. Successful risk management requires the development of a strategy for implementing the chosen course of action, and relies on experienced staff to put it into effect. It is also important to monitor the impact of implementing such decisions to determine whether the intended goals are being met.



Inspectors visit food production facilities to ensure that the products meet regulations and are safe for human consumption.

In this regard, levels of human exposure to environmental contaminants may be monitored over time. There are a number of ways of monitoring human exposure to contamination. For example, volunteers in selected areas of the country may be asked to wear devices that keep track of their exposure to pollutants in the surrounding air over a period of time. Food and drinking water may be analyzed for the presence of pollutants. Biological monitoring, which relies on analysis of samples of body fluids or tissues to indicate exposure, may also be done.

Reviewing the Decision

Decisions are reviewed periodically, especially when new information about a hazard or its risk is obtained, or if problems occur. The whole risk determination process proceeds in a dynamic fashion to continually evaluate whether the decision is still relevant. This ongoing review ensures that the Department continues to meet the challenges of protecting the health of Canadians.

A Two-way Dialogue on Risk

All Canadians can help to determine health risks from the environment. Government bodies may act to reduce risks, but it is important for Canadians to voice their concerns, their objections, and their acceptance of efforts to respond to environmental health problems. It is equally important for the government to keep Canadians informed so that they can make decisions based on scientific knowledge. A two-way dialogue on risk will ensure that the concerns of Canadians are being put into public policy.

Managing Radon Risks: An Example of the Risk Determination Process

In recent years public concern has increased over the potential harm to the health of a person who is exposed to radon at home. In response, Health and Welfare Canada is using the risk determination process to assess and manage health hazards that may be posed by radon. Some of the steps in the process are:

Hazard Identification

Scientific studies done in a number of countries including Canada have linked radon with deaths from lung cancer in underground miners exposed to the gas. Based on an evaluation of both the epidemiological and toxicological data, the International Agency for Research on Cancer has declared radon a known human carcinogen.[176]

Risk Estimation

From studies showing a relationship between radon and cancer, scientists estimated how much risk radon posed. Because most of the studies involved miners at work, scientists had to use these data to estimate the risk to people exposed to radon in their homes.

Making a Decision

Based on the assessment of risk, and taking into account the costs of dealing with radon exposure, Health and Welfare Canada chose to set a voluntary guideline for levels of radon in homes. The Department has established an exposure guideline at 800 becquerels per cubic metre, averaged over a year in a normal living area. This recommended level is comparable to those established in several European countries.[176] While radon is a health concern, it does not produce an emergency situation. Therefore, the Department recommends that people act to reduce radon concentrations within a year when the guideline is exceeded where they live.

Continued Monitoring

While a decision has been made to set a guideline, the risk determination process does not end there. Health and Welfare Canada will continue to conduct studies and update the guidelines if such studies show the need for this. For example, the Department is conducting a large-scale study in Winnipeg to obtain more information on the risks of exposure to radon in the home. It is expected that the study will provide useful new data against which current exposure guidelines can be evaluated.

Chapter Nine
Working Together for a Healthy Environment

Canadians are becoming increasingly aware that everyone must take responsibility for making the world a safer, healthier place to live. A worldwide, co-operative effort can produce lasting changes that will protect our health and that of future generations. Action to improve the environment and its effect on health must occur at a variety of levels: international, national, regional, community, and individual.

Concern about the health effects of environmental contaminants is global. We need to have a broad perspective on environmental problems, for the health of everyone on this planet is at stake.

International Developments

Concern about the health effects of environmental contaminants is global. Climate change, for example, will affect the entire world, and acid rain falls over thousands of square kilometres, without respect to national borders. As well, individual countries create environmental and health problems in the form of air and water pollution, or radiation. We need to have a broad perspective on environmental problems, for the health of everyone on this planet is at stake.

Fortunately, important developments on health and the environment are taking place at the international level. The World Health Organization, for instance, is involved with two initiatives aimed at achieving world health: Health for All, and sustainable development.

Health for All

The World Health Organization's program, Health for All, aims to achieve health for the world's population by the year 2000. Health in the context of this program is defined as a level of well-being that will enable people to lead economically and socially productive lives. In this sense, health is seen as a resource for everyday living, to satisfy people's needs and to improve the environment.

Introduced at the World Health Assembly in 1977, Health for All recognizes that improving health means improving our environment. Dr. Halfdan Mahler, then Director General of the World Health Organization (WHO), noted that "physical well-being means much more than the biology of the human body: it includes a safe environment and the responsibility for our physical surroundings on the planet as a whole."[177]

Health for All calls on several sectors of society to take part in making environments more conducive to good health. "Health does not exist in isolation," Dr. Mahler wrote about Health for All. "It is influenced by a complex of environmental, social and economic factors ultimately related to each other.... Health for All is a holistic concept calling for efforts in agriculture, industry, education, housing, and communications just as much as in medicine and public health."[177]

Health for All has been further developed, particularly for industrialized nations, by introducing the concept of health promotion – the process of enabling people to increase control over their own health. The World Health Organization considers this concept to represent "a mediating strategy between people and their environments," thus recognizing the importance of people's physical and social environments to their health.

The Ottawa Charter

In 1986 the World Health Organization, along with Health and Welfare Canada and the Canadian Public Health Association, held a major international conference that resulted in the Ottawa Charter for Health Promotion.

The Charter sees health as concerned with the interaction between the person and the environment. It recognizes that the elements of our social environment – including peace, shelter, education, food, income, social justice, and equity – are all prerequisites for health.

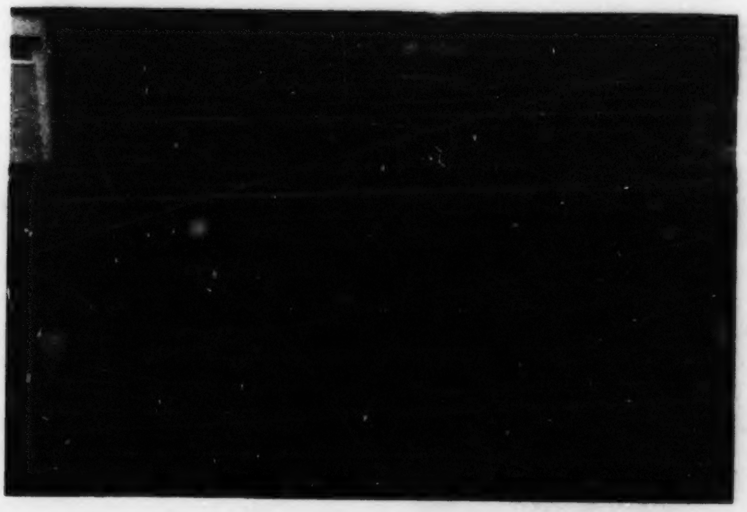
For the first time at an international level, the Charter recognized the fact that our *physical* environment is important to health, and pointed out the need for a "stable ecosystem and sustainable resources." As well, it called for the creation of "supportive environments."

The Charter noted that conserving natural resources throughout the world should be emphasized "as a global responsibility" and that protecting "the natural and the built environments" and conserving natural resources must be part of any health promotion strategy.[177]

The Ottawa Charter for Health Promotion

The Ottawa Charter for Health Promotion contains five strategies for creating healthy communities:

- to make public policies that include an awareness of health concerns. It is important to realize that many of our public policies may have health implications that were not intentional. Building "healthy public policy" means ensuring that policy decisions in all sectors – from housing to transportation to the environment – are conducive to good health. Legislation, regulation and education are some of the means that could be used to help integrate health concerns into our decision making. Co-operative action between sectors should lead to safer goods and services, healthier public services, and cleaner, more enjoyable environments.
- to create supportive environments. In its broadest terms, our environment includes the natural environment, the "built" environments where we live and work, and the social environment in which we interact with others. Supportive environments are those in which living and working conditions are safe, stimulating, satisfying and enjoyable. Health promotion works to create such environments by encouraging us to take care of each other, our communities and our natural environment. It also emphasizes that the conservation of natural resources should be a global responsibility.
- to strengthen community action. Community action is an important ingredient in creating healthier environments. It can be increased by giving people opportunities to have meaningful input into decisions that affect their health. Providing information and learning opportunities about health concerns, creating networks, and supporting communities with funds are also ways of strengthening community participation.
- to develop personal skills. Personal skills enable people to exercise control over their own health and their environment. Health promotion provides information and support in increasing these life skills. Strengthening these skills should take place through educational, professional, commercial and voluntary organizations.
- to reorient health services. Health is more than freedom from disease. While active treatment of health problems will always be needed, attention must also be given to preventive health care and promotion and, as well, to a more comprehensive approach to health care. This responsibility is shared among individuals, community groups, health professionals, health services, and governments. All of us must work together to produce the best possible health care system.[178]



It is essential that our use of natural resources and the environment does not harm the health of present and future generations.

Health and Welfare Canada's national health promotion strategy, Achieving Health for All, is closely linked to the Ottawa Charter. It is based on the philosophy that health is a resource for living and that supportive environments are essential for good health.

Sustainable Development

"Sustainable development" is the concept that today's use of resources and the environment should not damage prospects for their use by future generations. The term was first coined in 1980 in a report by the International Union for the Conservation of Nature. Highlighted in the 1987 Report of the World Commission on Environment and Development, the idea of sustainable development shares many of the same objectives and themes as Health for All.

The Commission's report, *Our Common Future,*[179] argues that a balance must be achieved between economic development and preserving the environment, so as to replenish resources and end wasteful depletion. It must allow, as the report's title suggests, the survival and prosperity of future generations.

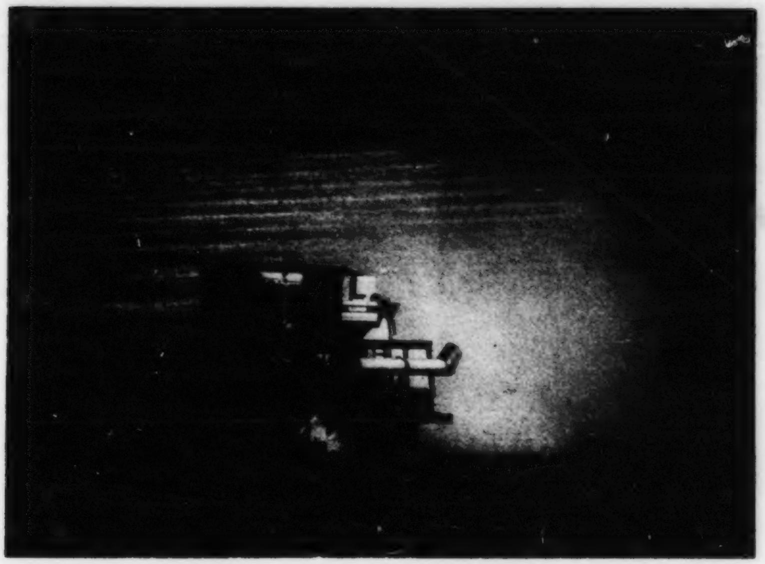
The report acknowledges that the economic development of industrialized nations promotes economic efficiency and use of technology, rather than valuing the environment and people. It suggests that giving priority to economic development over preserving the environment is no longer valid, and threatens the health of future generations. While economic development is essential to fulfil our basic survival needs, it cannot continue at the expense of people and the environment.

A change "in the content of growth, to make it less material- and energy-intensive and more equitable in its impact" is needed, the report says. "The objectives of growth must now include: maintenance of the earth's resources, improvement in the distribution of income, and support for human needs like education, clean air and water, and health."[179]

While the report looks at the global environment and economy, health is a basis for the concept of sustainable development. The Commission writes that "good health is the foundation of human welfare and hence a broad-based policy is essential for sustainable development."

Indeed, Commission Chairperson Gro Harlem Brundtland, after whom the report is sometimes called, said in 1988 that "ultimately, the whole report is about health." This makes sense, because the primary reason for changing our economic development is to ensure that future generations can lead productive, healthy lives.

In relating health to a variety of factors including the environment, economic development and social and cultural values, the report also recognizes that improving health involves much more than just health care.



Long-term climate changes may result in major modifications in the way land is used, particularly for farming.

"Integrated approaches are needed that reflect key health objectives in areas such as food production; water supply and sanitation; industrial policy, particularly with regard to safety and pollution; and the planning of human settlements." Vulnerable groups and risks to their health should be identified and the social and economic factors underlying these risks dealt with.[177, 179]

The concept of sustainable development has received some criticism. Some people feel that the approach, by calling for both conservation and development, is contradictory and impossible to achieve. Others feel that politicians and industries are using the concept as an excuse for unfettered economic expansion. Nonetheless, many countries around the world have embraced the idea as one that includes both the need for economic development and for a clean environment and good health.

The Canadian government has indicated support for the Commission. The 1988 Speech from the Throne said the call for sustainable development "holds that the state of the world's environment, the strength of the global economy and the health of the earth's inhabitants are inextricably linked."

A Merging of Ideas

Health for All and sustainable development have many similarities and seem to be coming even closer together with time. Both are integrated approaches to health, recognizing that our health is linked to the environment and to our social, cultural and economic values. Both call on people in all walks of life, not just in the health sector, to work towards improved health.

At the Second International Conference on Health Promotion in Adelaide, Australia, in 1988, an emphasis was placed on creating supportive environments for health, as an example of a shift to a closer relationship between Health for All and sustainable development.

The conference recognized that "the extremely diverse but limited natural resources which enrich life are essential to the continuing survival, health and well-being of the human race." It called on the World Health Organization to press for the acceptance of such principles and to support the concept of sustainable development.[177] As well, a committee to review the World Health Organization's activities in light of the Brundtland Report was established. In 1988 it noted the links between health and sustainable development and identified ways in which the organization's work is relevant to the latter.[177]

WHO's Third International Conference on Health Promotion also focused on environment and health, using the theme "Supportive Environments for Health." Held in Sweden in June, 1991, the conference aimed at finding practical ways to create physical, social and economic environments supportive of health and compatible with sustainable development.

These stronger connections between Health for All and sustainable development are an excellent indication that, more and more, environmental issues are seen in the light of the individual person's health.

Climate Change

In 1989, Canada was one of 67 countries participating in a conference in the Netherlands on atmospheric pollution and climate change. It resulted in the Noordwijk Declaration on Climate Change,[181] calling on all countries to start to control, limit or reduce emissions of greenhouse gases, with the goal of stabilizing concentrations of these gases in the atmosphere. The Second World Climate Conference in Geneva in 1990 resulted in Canada and 22 other nations agreeing to stabilize the emissions of greenhouse gases at 1990 levels by the year 2000.

The Noordwijk declaration calls on countries to preserve forests, prevent soil erosion, and reduce the chances of land becoming desert, as well as to increase efforts to find sources of renewable energy and ways to reuse carbon dioxide.

As well, the declaration recognizes the need for changes in attitudes and lifestyles. It asks all countries, particularly industrialized ones, to recognize the need to promote socio-economic activities and lifestyles that are environmentally sound. The declaration also calls for better ways to inform people and increase their awareness, and urges participation by non-governmental organizations.

The Great Lakes

The Great Lakes Water Quality Agreement is another important international agreement that considers the health of Canadians. Signed in 1972 by Canada and the United States, it commits the two countries to programs and other measures to restore and maintain the waters of the Great Lakes Basin. The Agreement has since been renewed and expanded twice, in 1978 and 1987.

The Montreal Protocol and Ozone Depletion

Ozone depletion could potentially result in serious health effects, including increased incidence of skin cancer, eye damage, and immune system diseases. Recently, countries around the world have responded to this environmental and health threat by taking action to stop the production of the industrial chemicals – primarily CFCs, halons, carbon tetrachloride, and methyl chloroform – that deplete the ozone layer.

One of the most important meetings on protecting the ozone layer took place at an international conference in Montreal in September, 1987, where 24 countries including Canada signed the Montreal Protocol on Substances that Deplete the Ozone Layer. These countries agreed to cut their consumption of CFCs to 50 percent of the 1981 level by 1998, and to freeze their consumption of halons at the 1986 level by 1992. Canada was one of the key players in the international negotiations that led to this ground-breaking agreement, and was among the first nations to ratify the Protocol, which came into force January 1, 1989.[180]

The Montreal Protocol was amended at meetings in London, England in June 1990 in order to tighten existing controls and add new provisions. Industrialized countries that have ratified the Protocol must phase out the production and consumption of CFCs, halons, and carbon tetrachloride by the year 2000, and methyl chloroform by 2005.[181]

The International Joint Commission (IJC) monitors the agreement. The Commission itself is a binational organization established in 1909 by the Boundary Waters Treaty. Through the Commission, Canada and the United States co-operatively resolve problems along their common border, including water and air pollution.

Every two years the IJC reports to the two federal governments on the quality of Great Lakes water. In its fifth report in 1989, the Commission emphasized the risk to human health posed by the continuing pollution of the lakes. It pointed to the numbers of wildlife species in the Great Lakes Basin that have problems reproducing, and to research done on mothers and children eating fish from Lake Michigan. The Commission concludes that "persistent toxic chemicals in the Great Lakes environment also threaten human health."[182]

The Commission's report suggests that both countries should expand their programs to include the study of more subtle, lifetime effects – such as decreased mental development – caused by toxic chemicals, rather than concentrating solely on cancer risk. The Commission asks the two countries to fund more research on studies that have shown a relationship between chemical exposure and human health and, as well, to identify other exposed populations and biological species and investigate the effects of chemical exposures on them.

Ecosystem Objectives for the Great Lakes Basin and Lake Ontario

The Lake Ontario ecosystem is a populated and industrialized area that provides drinking water for an estimated five million people and is a valuable part of the Great Lakes fishery. It is a priceless resource. Since the 1750s, human settlement and activity around Lake Ontario have resulted in increasing disruption of the ecosystem. Some of the more significant ecosystem stresses have been: deforestation, loss of wetlands, excessive input of nutrients, chemical contamination, invasion of species not native to the area, and overharvesting of resources. Lake Ontario can never again be the ecosystem it was in 1750, but a desirable target lies between what it was then and what it is now.

The Great Lakes Water Quality Agreement (GLWQA) was first signed by the governments of Canada and the United States in 1972, recognizing the need to restore water quality in the Great Lakes watershed. The Agreement was to be based primarily on the chemical content of the water. When the Agreement was revised in 1978 and again in 1987, an ecosystem approach to restoration and maintenance was adopted that takes into account the interdependency of all the parts of the ecosystem: plants, animals, air, land, water, and, of course, human beings. In 1985, ecosystem indicators were adopted by the GLWQA for Lake Superior; these indicators are organisms that indicate that the ecosystem is healthy if they are a stable, self-reproducing population. Following the 1987 revisions to the Agreement, the Ecosystem Objectives Working Group was established for Lake Ontario.

In addition to establishing goals, the Working Group developed the following five objectives for the Lake Ontario ecosystem:

- *Aquatic Communities.* The waters of Lake Ontario shall support diverse healthy, reproducing and self-sustaining communities of organisms, with an emphasis on native species.
- *Wildlife.* The perpetuation of a healthy, diverse and self-sustaining wildlife community that uses the lake for habitat and food. Both shall be ensured by maintaining and sustaining the waters, coastal wetlands and upland habitats of the Lake Ontario basin in sufficient quality and quantity.
- *Human Health.* The waters, plants and animals of Lake Ontario shall be free from contaminants and organisms resulting from human activities at levels that affect human health or aesthetic factors such as tainting, odour and turbidity (murkiness).

- *Habitat.* Lake Ontario offshore and nearshore zones and surrounding tributary, wetland and upland habitats shall be of sufficient quality and quantity to support ecosystem objectives for plants and animals in and adjacent to Lake Ontario.
- *Stewardship.* Human activities and decisions shall embrace environmental ethics and a commitment to responsible stewardship.

Once indicators have been selected by the Working Group, it will be possible to chart the fulfilment of the objectives above, and, in so doing, map the recovery of the Lake Ontario ecosystem.[163]

Figure 36 shows 43 areas of concern that have been identified on the basis of known pollution sources that have the potential to pollute (or have been proven to pollute) the waters in the Great Lakes Basin.

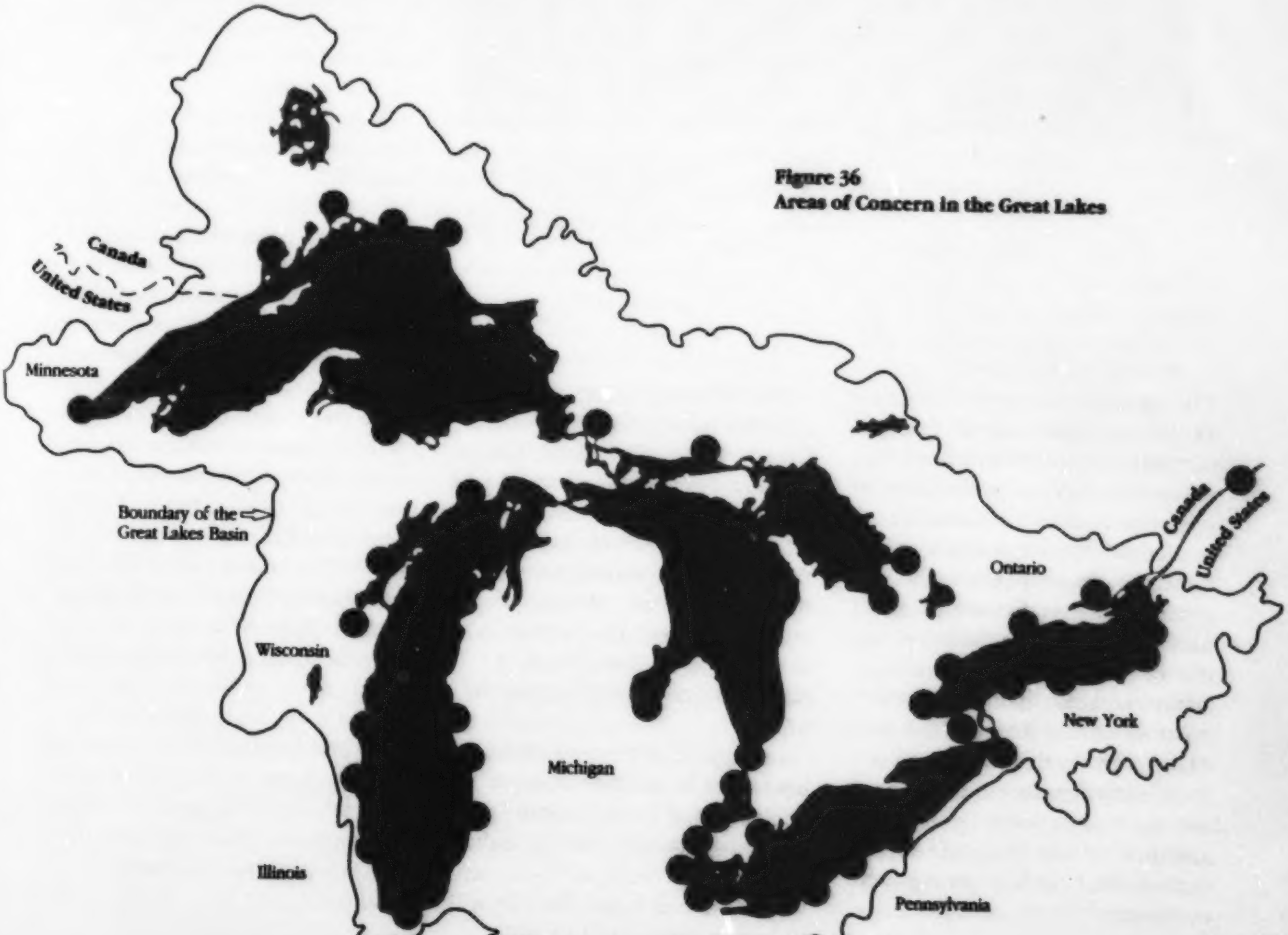
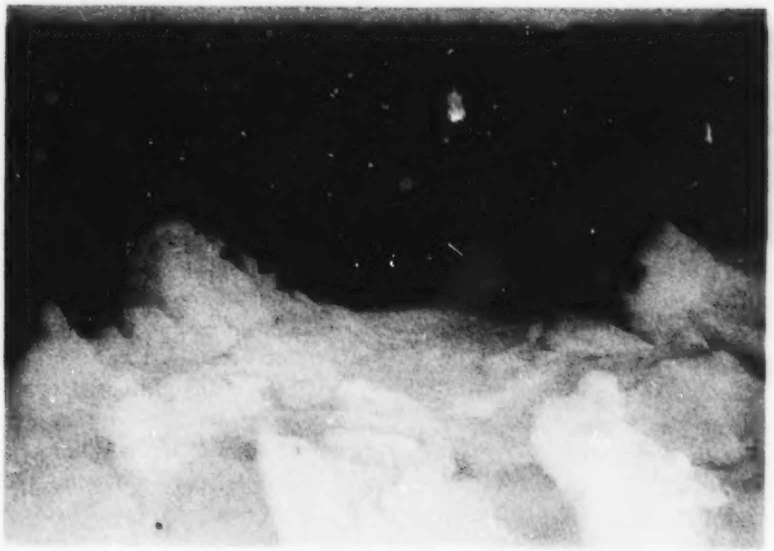

Canada
United States
Minnesota
Boundary of the Great Lakes Basin
Wisconsin
Illinois
Indiana
Michigan
Ohio
Pennsylvania
Ontario
New York
Canada
United States

Figure 36
Areas of Concern in the Great Lakes



The Arctic is particularly sensitive to pollution, and many of the region's people and cultures depend directly on a healthy environment.

The Arctic

In 1991, the Government of Canada (through Indian and Northern Affairs Canada) and seven other circumpolar countries adopted a comprehensive Arctic Environmental Protection Strategy (AEPS).

The Strategy calls for a co-ordinated attack on the problem of the transport of persistent organic contaminants, heavy metals and other pollutants to the Arctic. The Strategy recognizes that this region is particularly sensitive to pollution and much of its human population and their culture is directly dependent on the health of the region's ecosystem.

The AEPS represents the first time that all eight Arctic countries – Canada, Denmark, Finland, Iceland, Norway, Sweden, the former Soviet Union and the U.S. – have agreed to work co-operatively to protect the Arctic environment. Integral to the success of this effort has been the full involvement of people who are indigenous to the Arctic in developing and implementing the AEPS.

In support of this and other international initiatives, Canada is implementing its own Arctic Environmental Strategy (AES) – under the federal Green Plan[184] – to deal with these problems. The AES will be undertaken by Indian and Northern Affairs Canada in co-operation with non-government organizations, territorial governments and other federal departments. An action program is being implemented to:

- identify contaminant sources and their transport to the Arctic;
- assess contaminant levels in fish and wildlife;
- assess the effects of contaminants on the health of northern ecosystems including human health;
- provide timely health advice to Northern people; and
- establish international controls through agreements and co-operation with other countries and the circumpolar community.

These actions may help to renew confidence in country foods (traditional Native foods) as a safe diet.

Assessing Human Exposure

Another international project, the Human Exposure Assessment Location Project (HEAL),[185] is sponsored by the World Health Organization and the United Nations Environment Programme (UNEP).

HEAL comes under the auspices of the Global Environment Monitoring System (GEMS), run by UNEP. GEMS monitors environmental pollution at its source, while HEAL monitors the human health effects of these pollutants.

Traditionally, pollution was monitored only at its source. Now, however, it is apparent that pollution must also be studied by measuring human exposure. Researchers can then develop strategies to control pollution and protect not only the environment, but also human health.

HEAL's four specific objectives are:

- to provide comparable assessments of human exposures to environmental pollutants around the world and to identify trends;
- to improve, test, co-ordinate and demonstrate methods for monitoring human exposure;
- to promote the assessment of human exposure as a basis for strategies to control the environment to protect human health; and
- to improve the capability of countries, especially developing countries, to monitor exposure to pollutants.

Countries taking part in HEAL study human exposure to selected pollutants, producing new data on human exposure in different parts of the world. The findings are then used by the UNEP/WHO Secretariat to help all countries improve their programs for monitoring and assessing human exposure. For example, the Secretariat summarizes findings, distributes bibliographies of research papers on the subject, and holds technical workshops for researchers.

As more countries become involved in this venture, UNEP and WHO expect that assessing human exposure will become an integral part of environmental policy.

Toxic Chemicals

In 1976, UNEP established an agency to provide public information on toxic chemicals. Health and Welfare Canada is the National Correspondent for this International Registry of Potentially Toxic Chemicals (IRPTC). That is, the Department collects Canadian information and sends it to the international body, as well as responding to questions from other countries. Since 1988, IRPTC information has been made available on-line throughout Canada by means of telecommunications networks.

The purpose of the register is twofold: it collects and stores data, and operates a global network to exchange that data. Specifically, it collects information on chemicals liable to enter and damage the environment.

The two broad types of information that the register collects are:

- information on the behaviour of chemicals. This data is collected from national and international institutions, universities, industries, private data banks, libraries, academic institutions, scientific journals and other United Nations bodies such as the International Programme on Chemical Safety.
- information on chemical regulations, largely contributed by national correspondents of the register.

These two types of information permit an assessment of the risks posed by a chemical to human health and the environment.[186]

The register is an important source of information for professional people in science and industry because it makes data on chemicals readily available and identifies the potential hazards of using certain chemicals. The register can also be used to locate and draw attention to major gaps in available information, and encourage research to fill those gaps. Governments, industry and private individuals find the register useful as it assembles information on existing policies for control and regulation of hazardous chemicals at national, regional and global levels. The list now contains information on the behaviour and toxicity of more than 900 chemicals, and regulatory information on more than 9 000.

Chemical Safety

Three international organizations – the World Health Organization, the International Labour Organization, and the United Nations Environment Programme – collaborate to provide risk assessments on health and the environment in the International Programme on Chemical Safety (IPCS).

The program was established in 1980 to extend and strengthen the United Nations' evaluations, testing, and technical co-operation regarding the effects of chemicals on human health and the environment. Canada is a member of IPCS, and collaborates with the World Health Organization on international studies of genetic effects in humans that may be caused by factors in the environment, and on the human health implications of chemicals in foods.

National Developments

Under the 1944 Department of National Health and Welfare Act, Health and Welfare Canada is responsible for promoting and preserving Canadians' health, social security, and social welfare. This includes acting to improve the health and well-being of Canadians as they are affected by the environment.

The latter entails both protecting Canadians from potential health hazards posed by the environment, and promoting the creation of environments conducive to good mental and physical health. Such environments may be natural or built.

Toxic substances can be harmful to humans if these substances are not used wisely. The Canadian Environmental Protection Act is intended to control toxic substances from their creation through to their disposal.

Methylmercury Program in Native Communities

Canadian hydro-electric projects, built over the last 30 years, have resulted in elevated water levels in lakes and rivers fished by local Native people. Greater amounts of submerged vegetation in these flooded areas increase the rate of conversion of naturally occurring mercury into methylmercury, which readily moves up the food chain and can cause health problems.

The Methylmercury Program, established by Health and Welfare Canada, is intended to provide a monitoring program for Native Canadians who may be exposed to elevated mercury levels in their diet. This is an ongoing program that tracks the methylmercury concentration found in human tissue and allows Native people to weigh the risks and benefits of consuming fish and to make informed decisions concerning their diets.

Developing Options

Once a risk has been identified and evaluated through scientific procedures, options for dealing with that risk must be developed. The options are many and include regulations, advising other federal or provincial departments, proposing economic measures, setting voluntary standards for manufacturers, and providing information to the public.

Regulations and Guidelines

Regulations and guidelines are the most direct way governments have of dealing with health hazards. Such regulations are usually made under either federal or provincial legislation. Problems of overlapping jurisdiction are normally resolved through close co-operation between both levels of government.

The Federal Environmental Assessment and Review Process

The purpose of the federal Environmental Assessment and Review Process (EARP) is to examine proposed projects having some federal government involvement or decision-making capacity, ensuring that they will not damage the environment or human health.

In the past, environmental assessment was governed by guidelines that require all projects to be assessed for their impact on the environment. If there is the possibility that a project may have significant environmental effects, an independent review panel is set up to examine the proposal and advise the federal government on whether or not, and under what conditions, a proposal could proceed. The panel review includes testimony by the public as well as scientific experts.

Many of these panel reviews have included concerns over human health. For example, a review of the construction of a second nuclear reactor at Point Lepreau in New Brunswick included discussions of the potential health risks associated with radiation, particularly cancer and genetic disease.[187]

As part of the federal government's Green Plan, this environmental assessment process is being revised. The guidelines will be formalized into legislation called the Canadian Environmental Assessment Act, and an independent agency will be set up to administer it.[188]

Health is given an important place in both the current process and, more formally, in the proposed legislation. It defines the environment as including all living organisms, and environmental effects as including any impact on health and socio-economic conditions. Authorities will have to consider the impact of a proposed project on health, as well as on the natural environment.[187]

Federal legislation that relates to both the environment and health includes the Food and Drugs Act and Regulations (administered by Health and Welfare Canada), the Pest Control Products Act (administered by Agriculture Canada), the Hazardous Products Act and Regulations (administered by Consumer and Corporate Affairs Canada), and the Canadian Environmental Protection Act (jointly administered by Environment Canada and Health and Welfare Canada).

Guidelines are an effective, but less forceful way of obtaining compliance with health-based recommendations. For example, guidelines are developed for drinking water and recreational water. These guidelines are used by many jurisdictions to judge the quality of water and to take remedial action if they are exceeded. Because they do not involve the official regulation-making process, guidelines can often be developed more rapidly, and changed to respond quickly when new information becomes available.

Advice

If Health and Welfare Canada perceives a health risk involving an environmental issue that belongs in the hands of another department or falls within provincial jurisdiction, the Department can provide advice. The Department has, for example, established committees with provincial and territorial governments on the issues of drinking and recreational water, and indoor air quality. The committees have created guidelines for each of these areas which, while not legally binding, can exert pressure through moral suasion and can be used by provincial and territorial governments in creating their own regulations.

Within the federal realm, Health and Welfare Canada is often called upon to give advice about environmental risks to health to other departments such as Consumer and Corporate Affairs, Fisheries and Oceans, Agriculture, Labour, and Environment. The Department may also participate in interdepartmental programs on health and environment.

Health and Welfare Canada may provide advice and information to companies and ask them to voluntarily comply with product standards rather than apply strict regulatory controls.

The Canadian Environmental Protection Act

The Canadian Environmental Protection Act (CEPA), passed in 1988, gives the federal government stronger powers to regulate the use of hazardous substances. Administered jointly by Environment Canada and Health and Welfare Canada, the Act aims to protect both the environment and human health from dangerous or toxic substances.

CEPA requires Environment Canada and Health and Welfare Canada to prepare and publish a Priority Substances List that identifies substances – including chemicals, groups of chemicals, effluents and wastes – that may be harmful to the environment or health. The Act also requires both departments to assess these substances to determine if they are toxic. Under CEPA, a substance is considered toxic if it enters the environment in amounts that may:[189]

- harm the environment (for example, PCBs can accumulate in fish and cause reproductive problems in the wildlife that eat the fish).
- endanger the environment on which human life depends (for example, CFCs deplete the ozone layer, and increase exposure to ultraviolet radiation, which may increase the risk of skin cancer).
- endanger human life or health (for example, lead can harm the development of the human nervous system).

According to this definition, toxicity depends not only on the toxic properties of the substance, but also on the amount of the substance to which humans are exposed. Information on toxicity is obtained from short- and long-term testing in experimental animals and from studies of disease patterns in humans, and may indicate, for example, a substance's potential to cause cancer. Researchers assess exposure by examining information on the amount of a substance with which the population comes into contact – the higher the exposure, the greater the risk to human health.

If a substance is assessed as toxic, it will be removed from the Priority Substances List and may be placed on the List of Toxic Substances and become subject to regulations. The Canadian Environmental Protection Act is intended to control toxic substances over their entire life cycle, including their development, manufacture, transportation, distribution, use, storage, and disposal.[189]

So far, dioxins and furans,[190] and effluents from pulp mills using bleaching have been assessed. All have been classified as toxic under the Act, and regulations have been proposed to control their emissions. The List of Toxic Substances also contains substances such as PCBs, lead, mercury and asbestos, which were controlled under CEPA's predecessor, the Environmental Contaminants Act.

An Interdepartmental Effort: The Great Lakes Action Plan

In recent years there has been an increasing interest in the Great Lakes ecosystem, and in the health of the large numbers of people living in that region. The Great Lakes Health Effects Program, administered by Health and Welfare Canada, addresses many of these concerns. The program is a part of the Great Lakes Action Plan, an interdepartmental program involving six federal departments: Agriculture Canada, Environment Canada, Fisheries and Oceans, Public Works Canada, Transport Canada, and Health and Welfare Canada.

The five-year plan, announced in 1989, will operate until 1994. Within the Plan there are three distinct initiatives: the Great Lakes Cleanup Fund, to address the major areas of concern in this region; the Preservation Program for environmental quality and assessment; and the Great Lakes Health Effects Program.[190] In addition to the Great Lakes Action Plan, Environment Canada has launched a prevention initiative designed to get industry, public and governments working together to prevent the creation and release of pollutants.

The responsibilities of the Health Effects Program include monitoring the exposure of populations in the Great Lakes Basin to contaminants, studying what effects such exposure may have and finding ways for people to reduce their exposure. The program also has a strong commitment to the public, and has held public consultations and information sessions and produced public and media reports.[190]

A major federal government report on toxic chemicals in the Great Lakes released in 1991 states that citizens in the Great Lakes Basin are exposed to a wide variety of persistent toxic chemicals. It concludes that "elevated levels of contaminants in the Great Lakes Basin (and elsewhere) do pose a threat to health…."

The chemicals come from a number of sources including industrial processes, farms, leaking waste sites and emissions from combustion sources such as industrial and municipal incinerators, as well as motor vehicles.[191]

However, only a portion of our total exposure to environmental contaminants can be attributed to sources in the drainage basin of the Great Lakes. For example, a number of airborne contaminants arrive in the basin via the air from remote sources, and much of the food consumed by residents is grown outside the basin. As well, studies completed to date indicate that the general population living in the Great Lakes basin is probably not exposed to higher levels of the major pollutants than people who live in other North American urban centres. Exposure estimates for the general adult population are usually below established acceptable intakes.[191]

Despite these encouraging findings, specific subpopulations living in the Great Lakes Basin that consume locally caught fish or wildlife – that is, Native groups and anglers – or who live in highly contaminated areas may be exposed to higher levels of toxic chemicals than the general population. Fetuses and breast-fed infants could be exposed to higher levels of contaminants than the general population through placental transfer and breast milk. In addition, individuals who have respiratory diseases may be at greater risk from the effects of airborne pollutants in the basin.[191]

The precise nature and severity of the effects, the extent to which they exist and the specific populations affected are still largely unknown, and a great deal of research has yet to be done. Currently, a number of studies are being undertaken. These include: a community-based study – in partnership with Native people – of the exposure of Native people to environmental contaminants; an in-depth study of cancer incidence and birth deformities in the Great Lakes Basin; and epidemiological and toxicological studies designed to investigate the relationships between exposure to contaminants in the Great Lakes ecosystem and a wide variety of effects – especially those on the immune system, reproduction, and infant development. The Department is conducting public participation workshops in communities around the Great Lakes, and preparing information kits based on the most recent scientific information.

Economic Measures

Where there are no regulations for environmental hazards and where making regulations would not be feasible, a variety of economic measures may be used. In some instances economic measures can be used as a substitute for regulation or to reinforce regulations. By using market forces, economic incentives (such as charges for effluent and waste disposal, tradeable waste-emission permits, deposit/refund systems, and natural-resource use fees) can be used to stop or reduce pollution or encourage resource conservation.

Accidental spills of material can be harmful to the environment, but may not necessarily pose a risk to human health. Nevertheless, greater care and vigilance are needed to keep our environment clean and safe.

Emergency Response

The Emergency Services Division of Health and Welfare Canada maintains the health care delivery systems and emergency social services in a national emergency and in peacetime for disasters anywhere in Canada. Part of the Division's activities includes maintaining the National Stockpile Program[192] that includes:

- Two-hundred-bed emergency hospitals
- Advanced treatment centres
- Casualty collecting units
- Hospital disaster supplies
- Blood depots
- Mobile feeding units
- Reception centre kits

This program involves the purchase, packaging, shipping and storage of the above items in federal buildings, or medical depots of the Department of National Defence (DND) across the country. Most provincial health and social service agencies have similar units deployed to conform to their own emergency response plans. The Division also provides assistance and advice to provinces and municipalities in emergency health and social services planning.[192]

As a result of accidents such as the one at Three Mile Island near Harrisburg, Pennsylvania, the Canadian Government developed the Federal Nuclear Emergency Response Plan (FNERP). A nuclear emergency is defined as the release of radionuclides in a situation other than a nuclear war against North America. If there is a failure of a nuclear reactor in Canada, or in a neighbouring U.S. state, then provincial authorities play the lead role, with the federal government providing support. If the released radionuclides originate outside Canada, as happened with the Chernobyl reactor, then the federal government assumes the lead.[193]

Health and Welfare Canada maintains a duty officer 24 hours a day, seven days a week, through a nuclear emergency telephone number. Once a call is received, the duty officer contacts the co-ordinator, or a designated alternative, who can declare an emergency after consultation with the Minister. The heads of various groups (Co-ordinating Group, Operations Group, Technical Advisory Group and Public Information Group) are contacted, as are other government departments and provincial agencies, in order to handle the emergency.[193]

Information to Consumers

Another option is to give information to consumers, allowing them to make informed decisions about a risk. For example, the Department prepares *Issues*, a publication providing health information on a variety of subjects including food, drugs, medical devices, and pesticides.

We all make lifestyle choices that affect our own health. Outdoor activities can be an important part of a healthy lifestyle.

Promoting Healthy Environments

Creating a healthier environment involves researching health effects, lowering contaminant levels and monitoring risky situations. It also involves making important choices about the way we live.

Our immediate surroundings – our homes, workplaces and schools – and the way we interact with them are important to our health. Health promoters have long been aware of this, and movements to clean up water supplies and make homes and workplaces cleaner and safer have had a major health effect. That is why Health and Welfare Canada promotes lifestyle choices that protect health and the environment, and encourages individuals and communities to adopt a similar approach. The Department's promotion of health has two goals: to focus attention on the quality of life, and to provide frameworks for communities to start creating healthier spaces in which to live and work. The Department provides national leadership by developing and implementing programs that promote health and encourage the avoidance of health risks.

A Larger Vision

Professionals in health promotion define both health and the environment broadly. While our environment obviously includes our physical surroundings, it also includes economic conditions, social structures, psychological factors, systems of justice, and the prevailing attitudes of society.

There are very important health and safety considerations in our physical environment – that is, in our homes, schools, places of work and public spaces. As well, many people are caught in unhealthy social conditions, such as poverty and unemployment, and are sometimes kept there by discrimination.[194]

The fact that environments are both physical and social and that both aspects affect each other works in a variety of ways. For example, it has been well documented that many people living in poverty have less sanitary living conditions than others, and are more likely to exploit their environment in order to make a living.

Another example is lack of public participation in decision making. Many people feel that environmental problems are too large for them or their communities to make significant contributions to change – contributions that could have positive influences on their own health.

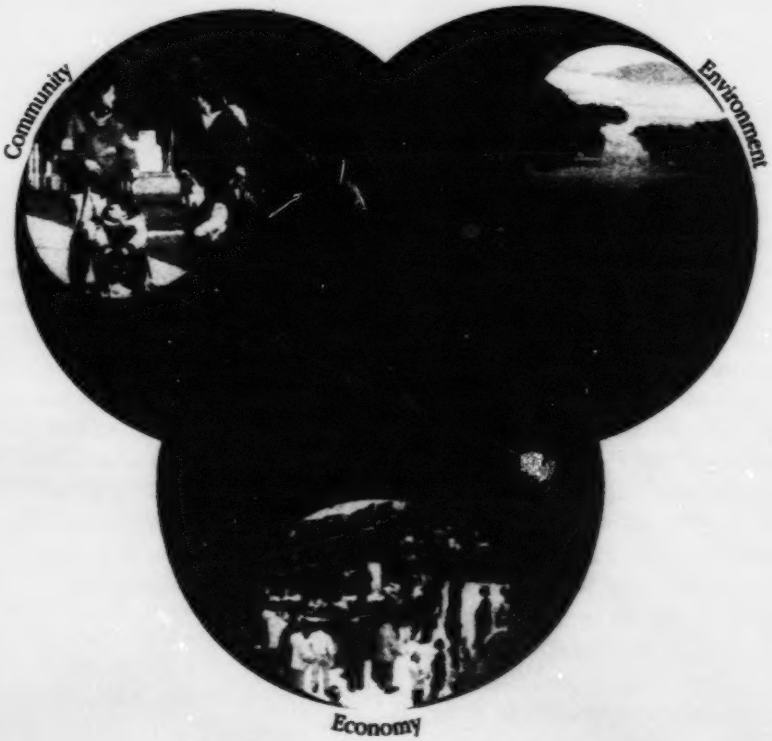
Finally, social attitudes that focus on short-term economic gain over long-term planning have meant that our society has, in the past, tolerated the fouling of air and water, conditions that now affect our health. It is precisely these social attitudes and conditions that health promoters aim to change when they try to improve the environment.

Health Relationship Between the Community, the Environment and the Economy

In May 1989, Health and Welfare Canada and Environment Canada held a conference at York University on "Environment, Health and Economy: Strategies for a Sustainable Future." The conference was intended to clarify the links between health, the environment and the economy, and to develop an action plan. A simple model was used to illustrate some of the connections between the three concepts.[177] More recently, the model was expanded to include the community (see figure 37). Health is viewed as dependent upon:[195]

- a level of economic activity that is *adequately prosperous*, so that not only are the basic prerequisites for health provided but so, too, is a generally high standard of living (since we know that health is clearly related to wealth);
- a natural environment that is *viable* – that is, supportive of life – not only for humans but for the other species that are part of our ecosystem;
- a community that is *convivial* – that is to say, one where the members of the community live together harmoniously, and there are supportive and rewarding social structures, and constructive interactions between individuals;
- an economic activity that not only is adequate to ensure health, but also is distributed *equitably* through the community to ensure that everyone's basic prerequisites for health are met and everyone has an equal opportunity to be healthy;
- an economic activity that is environmentally sustainable – that is, the needs of present generations can be met without compromising the prospects of future generations;
- a "built" environment of the city that is livable; it must support and encourage a convivial community and a high quality of life.

Figure 37
Health in Relation to the Community, the Environment and the Economy[195]



Broadening the Scope

Health promoters have become aware that health is much broader than just a physical state of well-being. A beautiful landscape, clean air and water, and safe and harmonious living and working conditions meet important mental and emotional needs for all of us.

Public Policies and Health

A somewhat different concept, "healthy public policy," places the onus on the government to consider the health implications of its public policies.

The Ottawa Charter for Health Promotion identifies healthy public policy as one of the ways in which healthy communities are built. Such policy "means putting health on the agenda of policy makers in all sectors and at all levels, directing them to be aware of the health consequences of their decisions and to accept their responsibilities for health."[178]

In the context of health and the environment, this means that policy should be reviewed for ways in which it affects health both directly and through changes to the environment.

A Change in Perspective

One of the first documents to solidify the link between healthy people and healthy environments was Health and Welfare Canada's 1986 report *Achieving Health for All: A Framework for Health Promotion*. It contained a new vision of health.

This vision sees health, part of everyday living, as "a resource which gives people the ability to manage and even to change their surroundings."[196] This definition recognizes the link between a person's health and surroundings, and also that a person must be able to increase control over that environment.

The report identifies three challenges to health: reducing inequalities, increasing the effort to prevent illness, and enhancing people's capacity to cope with illness. It also identifies three mechanisms for dealing with those challenges: self care, mutual care, and creating healthy environments.

Creating healthy environments, the report says, "means altering or adapting our social, economic or physical surroundings in ways that will help not only to preserve but also to enhance health. It means ensuring that policies and practices are in place to provide Canadians with a healthy environment at home, school or work or wherever else they may be. It means communities and regions working together to create environments that are conducive to health.

"From this perspective, the environment is all-encompassing; the concept of boundaries is inappropriate when we speak of the promotion of health. The environment includes the buildings where we live, the air we breathe and the jobs we do. It is also, for example, the education, transportation, and health systems. Because of the breadth and scope of the environment thus understood, environmental change becomes by far the most complex and the most difficult of the three mechanisms or kinds of action required for the promotion of health."[196]

The report recognizes that everyone must undertake to create healthy communities. Governments and businesses must establish policies and practices; individuals and groups must begin to change their surroundings.

Two Canadian initiatives to promote health have put into action the report's concept of creating healthy communities: the Canadian Healthy Communities Project (CHCP) and Strengthening Community Health (SCH). In both programs, environmental concerns are part of the local efforts to improve community health. These programs were merged in 1990 and are now referred to solely as the "Healthy Communities Project."

The Canadian Healthy Communities Project, linked with the World Health Organization's European program "Healthy Cities," is aimed at enhancing our quality of life by encouraging municipalities and the people living in them to make health a primary factor in political, social, and economic decision making.

The program, itself an example of co-operation to improve health and the environment, is a joint venture of the Canadian Institute of Planners, the Canadian Public Health Association, and the Federation of Canadian Municipalities, with funding from Health and Welfare Canada. It also helps communities to build a commitment to healthy environments through projects, communication, and co-operation. More than 100 municipalities are participating.

The second initiative, Strengthening Community Health, supports strategies for community collaboration and increased citizen participation in decision making.

Sherbrooke: A Healthy Community Pilot Project

The City of Sherbrooke in Eastern Quebec is a member of both Villes et villages en santé (the Quebec Healthy Communities network) and the Canadian Healthy Communities Project. As part of these two networks, the City has participated in a number of innovative programs related to health and environment.

For example, the City worked to increase the number of restaurants that provide non-smoking areas. It sent letters to 115 restaurants in Sherbrooke, inviting them to reserve 30 percent of their serving area for non-smokers. At the same time, a guidebook was prepared that suggested ways to set up a non-smoking section in a restaurant, and 2 000 "No Smoking" table cards were printed with the Healthy Sherbrooke slogan. These efforts got results; 50 percent of all restaurants in Sherbrooke with seating for over 40 people now provide non-smokers' areas.

The City also organized a "collection day" with the help of the University of Sherbrooke. Collection depots were set up around Sherbrooke to gather hazardous household wastes. Two hundred and ninety families participated in the collection, bringing in a total of 43 barrels of toxic waste (9 000 litres of dangerous products) that had been stored in people's basements and garages.

The City of Sherbrooke also has a number of plans for the future, which include continuing collaboration to reduce toxic wastes and the use of pesticides in the community.[113]

Sponsored by the Canadian Public Health Association with funding from Health and Welfare Canada, the program has resulted in a wide variety of undertakings. These range from creating provincial networks for co-ordination and communication, to sponsoring local workshops for skills development and training.

Communities and Health

In the press for environmental change, communities have always been important. "Think globally, act locally" is the slogan for the United Nations Environment Programme.

The community can be an important agent for promoting health which, in the past, was seen as the shared responsibility of physicians, scientists, researchers and other individuals. Now we know that the interactions between people and their communities have a great deal to do with health.

First, the people within a community share many of the same interests. For example, people living around the Great Lakes share the same concerns about the ways in which chemical pollution of the Lakes is affecting their health, concerns that are not shared by Canadians living in Western Canada or the Maritimes. Or a select group of people may be particularly vulnerable to a particular contaminant. They, too, form a community with shared interests. For example, people with respiratory ailments are more vulnerable to the health effects of outdoor air pollution than others.

Second, as well as having shared concerns, communities also have shared resources. For instance, people vulnerable to specific contaminants have experience with their problems and, by grouping together, can present this expertise in a way that may improve their living conditions. Another example would be people living in one area who lobby for their cause by forming a community group or working through their municipal governments.

Municipalities, indeed, have the advantage of being able to respond to environmental health issues in a way that is appropriate to local needs. In fact, since many of the factors contributing to a healthy community are outside the scope of the formal health care system regulated by the provinces and the federal government, the role of local government is of paramount importance.

In the nineteenth and early twentieth centuries, municipal governments made some of the most significant environmental health changes, including cleaning up local water supplies and air. We seem to be returning to a time when local governments and concerned community groups will again play a fundamental role in cleaning up the environment to improve health.

With the community at the forefront of both the environmental and health promotion movements, it is not surprising that it is seen as the focal point for important and fundamental changes in creating healthier environments for Canadians.

Together communities can achieve results that individuals alone could not, and that professionals might overlook. By concentrated effort to improve health as it is affected by the environment, communities can make enormous changes that could eventually be global in scope.

Public Participation

People want and need to have a say in decisions and policies that affect their own health. When they are able to take part in the decision-making process, their commitment to the outcome is increased and they are willing to assume more responsibility for their actions.

Enabling people to control their own environment, and thus their health, means sharing information, knowledge, skills and resources, and suggests a shift of power from professionals, institutions and bureaucrats to the public. This concept is crucial because people who can control their lives have a greater opportunity to be healthy and to prosper socially.[194]

A number of other reports and committees have emphasized the importance of public participation. The Brundtland Report, for one, stresses that it is needed to create community knowledge and interest, both crucial if we are to make long-term global changes.

An integral part of health promotion, too, is the idea of helping to involve people in controlling the physical and social conditions in their community. But in order for us all to benefit from such help, we must each realize the importance of taking some responsibility for our own health and we must be willing, if necessary, to adjust our lifestyles to promote it. Most of all, we need to know that, both individually and working together for the betterment of all, we can act to lessen environmental risk to health.

Chapter Ten
Next Steps

People in the community share many of the same interests and concerns about their health and their environment.

Regulations, government programs, scientific advancements and public health measures have eliminated many of the health hazards that affected us in the past. However, Canadians have expressed concern about how their health and the health of succeeding generations will be affected.

The federal government is also concerned with future environmental problems and has begun to implement a long-range plan to protect the Canadian environment and ensure the good health of its inhabitants. This process began in the summer of 1990 when Canadians were invited to express their opinions in public forums, and to suggest priorities for dealing with environmental problems. These consultations were the beginning of the federal government's Green Plan and involved the general public, environmental and special interest groups, professional associations, industry and all three levels of government. Health and Welfare Canada participated at all of the 41 information sessions and 19 consultation sessions held across Canada. Departmental personnel helped to answer questions and document carefully the concerns expressed by the other participants.

More than 4 480 recommendations were made by the participants on all aspects of the Canadian environment. About 1 878 (42 percent) of the recommendations were either directly or indirectly related to human health. There were 12 areas in which the health recommendations could be categorized: air quality, information and education, water quality, waste management, monitoring, regulations under CEPA, food quality, risk management, research activities, radioactivity, consumer products, and international and intergovernmental co-ordination.[197]

On December 11, 1990, the government presented details of the Green Plan.[187] A major component is the Action Plan on Health and the Environment (APHE), which will be carried out by Health and Welfare Canada. Along with the activities of several other government departments, the APHE will help ensure that Canada's environment continues to be a healthy place.

The Action Plan

Many of the initiatives proposed in the APHE will begin between 1992 and 1996. The APHE can be described in terms of four major areas that require action: regulation and monitoring, groups at risk, facilitating individual and community action, and international activities.

Regulation and Monitoring

In its role as advocate and protector of public health, Health and Welfare Canada can take action on a number of fronts. It will create new legislation and enhance existing regulations to reduce health risks associated with our air, water, soil and food. For example, the government will introduce legislation on drinking water safety and will accelerate the health assessment of chemicals under the Canadian Environmental Protection Act.

Monitoring hazards in the environment is essential to an understanding of the nature and extent to which our health is being affected. The Action Plan will implement programs that link pollutants to health outcomes such as the effects of airborne pollution on human respiration.

Groups at Risk

As discussed throughout this publication, some groups of Canadians may be more at risk from environmental hazards than others. Such groups include Natives and Northerners who depend on the natural environment for their regular diet and who may be at risk if their food sources are contaminated. Newborn infants and children are also particularly susceptible to high levels of pollutants. In order to ensure that certain groups of Canadians are aware of the risks posed by their environment, Health and Welfare Canada will assess the risks of environmental hazards for these groups and communicate the findings to those most affected. An example of this portion of the Action Plan is the Drinking Water Safety Program for Natives. It recognizes that drinking water on Native reserves may not always meet national standards and therefore the Department is providing water testing, water monitoring and training of Band members to identify and remedy drinking water problems.

Facilitating Individual and Community Action

During the Green Plan consultations, individuals and community members clearly stated that they have a role to play in future initiatives on health and the environment. Canadians are looking to the government to provide them with leadership and support to enable them to develop skills and take action on improving the environment and their health. The Action Plan will help inform people about how their own actions can make a difference to their health, while at the same time preserving and enjoying the natural environment. These "awareness" initiatives will interpret scientific information for the lay person and will help the community to promote healthy environments.

International Activities

Canada cannot act alone in ensuring that the public is protected from environmental hazards. We must continue to work with other countries in identifying health problems and proposing mutually beneficial solutions. The Action Plan will allow us to work with major international organizations dedicated to promoting and protecting the health of the earth's inhabitants. It will ensure that Canada has a voice in international forums, where decisions are made that can result in healthier environments for everyone.

The Challenge Before Us

The Action Plan on Health and the Environment is designed to deal with the major environmental health challenges that may face us from the environment in the next decade. By regulating and monitoring, by assessing groups at risk, and by fostering individual, community and international initiatives, we can continue to address the problems that concern us all.

While we are fortunate to be living in the relatively safe Canadian environment, it is becoming obvious that we must be vigilant in making decisions that preserve our health and that of future generations.

Appendix I
What You Can Do

The individual can contribute a great deal towards maintaining a healthy environment. There are many things you can do to help.

Indoor Air

Pollution of indoor air comes from a variety of sources including tobacco smoke, cleaning products, kerosene heaters, kitchen appliances, paints and varnishes, asbestos, and formaldehyde. Natural biological contaminants such as moulds and fungi can also cause health problems.

What You Can Do

- If you spot visible mould on surfaces such as windows or tile, or have a damp, musty basement, eliminate these problems before they make you sick. Dry out the room or whole house by opening some windows slightly, and by operating an exhaust fan; during the summer, use an air conditioner or a dehumidifier. You can remove mould by using a chlorine bleach or other suitable product.
- Substitute non-toxic alternatives for cleaning and personal care products.
- Thoroughly wash and disinfect room or furnace humidifiers regularly. Use a chlorine bleach diluted one part bleach to two parts water, and keep humidifiers dry when they are not in use. They are a breeding ground for potentially harmful bacteria and fungi.
- Try to get by without using home humidifiers. Often normal activities in the home, including washing and bathing, allow for comfortable levels of humidity. During the heating season, keep the relative humidity between 30 and 55 percent, and never more than 70 percent.
- Use distilled or de-ionized water to minimize the particle formation from ultrasonic humidifiers. These humidifiers can give rise to high levels of particles in indoor air and this situation can be harmful to your lungs.
- Try to avoid using paint strippers and other strong chemicals in the home as it is difficult to ventilate adequately; work outside if possible. Seek professional advice on how to safely remove paint that contains lead.
- If you use art supplies, look for books on the topic of art safety, or order a copy of *The Safer Arts* booklet from Health and Welfare Canada. Many art supplies such as glues, paints, varnishes and solvents are highly volatile and should be used only under very well ventilated conditions.

- Try to reduce your exposure to chemicals by airing out a new home for the first several months. New homes contain lots of chemicals in building materials and from new furnishings.
- Have your chimney, furnace and any fuel-fired appliance cleaned, adjusted and properly maintained regularly to minimize the chance of having carbon monoxide and other poisonous gases build up in the home. Make sure that there is adequate fresh air for all devices that use air in their operation – such as furnaces, fireplaces, wood-burning stoves,[100] exhaust fans and clothes dryers – otherwise toxic gases can back up into the home.
- Eliminate tobacco smoke in your home.
- Dust or vacuum regularly to get rid of dust particles and small insects such as mites. It may be worthwhile to get the heating ducts cleaned occasionally.

Outdoor Air

Outdoor air contains a number of pollutants, including nitrogen oxides, volatile organic compounds, and ozone. While much air pollution results from industrial activity, a great deal also results from transportation. In urban areas, exhaust from cars, trucks and buses is a particular problem. Car exhaust contains four pollutants that particularly relate to health and the environment: carbon monoxide, carbon dioxide, nitrogen oxides, and hydrocarbons.

What You Can Do

- Use cars much less frequently. Try using alternative forms of transportation such as buses or subways, bicycling, and walking.
- Use fuel-efficient cars and keep cars well serviced.
- Burning leaves, grass clippings and branches add to total emissions in our air. Consider recycling or composting organic materials instead.
- On days of high air pollution (smoggy or hazy days), reduce strenuous physical activity such as jogging.

Food

With the increasing awareness in our society about chemicals and the environment, there is a growing concern about contaminating our food. Although chemicals found in food are usually in small quantities, they are strictly regulated to prevent any effects of long-term exposure to such low levels.

What You Can Do

- If you have a garden where you grow your own vegetables, fruits and herbs and you use pesticides, follow label instructions exactly.
- Wash fruit and vegetables with water to get rid of any surface dirt that may contain traces of chemicals.
- Vary your diet to ensure that it includes enough of all the essential elements and to prevent an excess of any particular contaminant.
- Cook foods properly, especially meat and poultry (see Chapter Five, "Micro-organisms").

Handling Food Safely

While bacteria in food can cause considerable risk to health, this risk can be significantly reduced if you follow safe handling and cooking practices.

What You Can Do

Handling: Cooked foods should not come into contact with raw foods, so when you move cooked food from the barbecue or stove to the table, use a clean plate, rather than the one already used for the raw meat. It is also important to wash dishes, cutting boards and counters with hot soapy water and bleach after raw meat has been on them. Wash your hands before and after handling foods.[51]

Refrigerating: Because bacteria multiply faster at room temperature, it is important to keep raw foods cold until they are cooked. Raw poultry and meat should be refrigerated or frozen immediately after purchase. Meats should be thawed in the refrigerator rather than at room temperature.[107]

Cooking: Thorough cooking of raw poultry, meat and eggs will kill all the bacteria in the food. Poultry that is pink from undercooking should not be eaten. The same applies to ground meats such as hamburger. Eggs, especially those with cracked shells, should not be eaten raw or partially cooked.[51]

Barbecuing: Cases of food poisoning are more frequent during the barbecue season. This occurs because it is difficult to cook foods properly on a barbecue. Poultry can be pre-cooked in the kitchen for about 20 minutes before being placed on the barbecue. Hamburgers, too, can be a prime source of food poisoning if they are eaten rare, and should be well cooked on the barbecue.[107]

Drinking Water

Drinking water should meet guidelines for bacteria, chemicals, and radioactive substances. Urban water-treatment systems were originally designed to remove bacteria and viruses that can cause diarrhea and diseases such as cholera and gastroenteritis. Some strains of bacteria pose an immediate health threat and can cause illness and death. Chemical pollutants such as pesticides, solvents and metals, on the other hand, may pose a long-term risk to health.

What You Can Do

- Flush your tap first thing in the morning to get rid of accumulated chemicals and bacteria. Let it run until the water is as cold as it will get. To minimize wasting water, use the shower, toilet, etc., first, so as to flush most of the piping in the home.
- If you are doing plumbing repairs to copper pipe, use only non-lead solder – or make sure the plumber is using it. It is readily available in plumbing stores. If you use lead solder, the water may contain elevated concentrations of lead for quite some time.

- Most homes do not need a water treatment device. Unless you have a contaminated private water supply, you probably don't need one. Consult your municipality's water-treatment professionals. Ask about your local drinking water and help ensure that it is maintained at a good quality. Take a tour of your local water-treatment plant.
- If you want to use a treatment unit on your tap, ask the salesperson for the results of chemical tests on water treated by the device. Replace filters regularly to prevent the build-up of bacteria on your filter, particularly if you have an activated carbon filter. Purchase one that has been tested to National Sanitation Foundation specifications.
- If you are concerned about bottled water, ask the distributor for a copy of the bacteriological and chemical test results for the water and see how well it meets drinking-water guidelines for your province or territory, or the *Guidelines for Canadian Drinking Water Quality.*
- If you have a private well, have your drinking water tested for bacterial contamination at least twice a year. If your well is new, also have it tested for chemical contamination. Provincial health and environment agencies can advise you on how to get these tests done.
- If you have a water softener, do not drink the water treated by it. Hard water is considered better for health than soft water, and does not have the extra salt from the softener.

Recreational Water

Here are some tips to help you protect your health when you use recreational water:[114]

- Whenever possible, take a shower before and after swimming in a public place.
- Make sure that your children use the toilet before swimming.
- Avoid swimming if you have open sores, scrapes or scratches.
- Avoid swimming in lagoons or bays with very calm water if many other people are already swimming there. The same precaution should be taken for small, heavily frequented artificial lakes. Such places may be contaminated by micro-organisms from other swimmers.
- Find out how domestic waste water is treated at facilities located close to recreational water. Never swim in water into which household sewage or run-off from farms is dumped.
- Consult a doctor for any infection of the skin, eyes, ears, throat, stomach or intestines that you suspect may be the result of using water in a public place.
- When water in a recreational area is of doubtful quality, avoid games that require you to put your head under water or in which you may accidentally swallow it.
- When camping, avoid drinking water from lakes and streams. Boil water thoroughly before mixing it with other foods or before drinking.

Hazardous Household Garbage

Common household hazardous waste may include art supplies, batteries, pesticides, cleaning products, paints and solvents, used crankcase oil, pharmaceutical supplies, pool chemicals, propane cylinders, and wood preservatives.

What You Can Do

- Take your hazardous garbage from your home to a special collection depot.
- Try switching to other cleaning products. For example, use baking soda, vinegar and water as an all-purpose cleaning agent: 1/4 cup baking soda, 1/2 cup white vinegar, and 2 litres of water.
- Buy a battery recharger and rechargeable batteries, or use solar-operated batteries when possible. Dry-cell batteries for flashlights and radios contain heavy metals such as mercury and zinc and should not be thrown away with regular household garbage.
- Avoid getting acid from car batteries on skin and clothing as it is extremely corrosive. Car batteries can be traded in or given to service stations to recycle. Do not put them in your regular garbage.
- Always read instructions on product labels carefully and follow them closely.
- Ensure that any chemicals stored in the home are tightly sealed and in an adequately ventilated area. Keep flammable liquids out of the home if possible.
- Use a minimum of pesticides and follow directions for use or disposal. Often alternatives can be found, such as removing weeds by hand.

Radiation

Radiation in one form or another is an inescapable part of our lives. Exposure to high levels of radiation usually exists only in occupational settings where radioactive materials are used. In these situations, workers' health is protected by rigorously monitoring radiation levels and by instituting safe work practices. The general population receives radiation levels that are usually too low to pose a health hazard. However, there are some things each of us can do if we choose to limit our exposure to radiation.

- If you believe that radon is a problem in your home, consult the CMHC publications on housing design to determine where radon is entering. You may also wish to have the radon level in your home tested by commercially available methods (see Chapter Six).
- If your doctor or dentist is considering giving you X-rays, inform him or her about the number of X-rays you have had in the past year.
- Avoid prolonged direct eye contact with intense light beams such as lasers.
- Because of the effects of ultraviolet radiation, be cautious about the amount of time spent tanning, especially in intense sunlight. If you do spend a great deal of time outdoors, wear protective clothing, a hat or visor, and use skin lotion with an adequate sun screen factor (SPF-15 or more) that screens both ultraviolet A and B radiation.
- Stratospheric ozone protects us from excessive ultraviolet radiation and is depleted by chemicals such as CFCs. You could restrict your use of aerosol products that contain CFCs. You could also ask for freon gas to be collected and recycled when your fridge, freezer or air conditioner need repairs or are discarded.

Electromagnetic Fields (EMFs)

It is impossible to avoid EMFs completely because everyone is exposed to them from electric power lines and through the use of electrical devices such as appliances and computers. However, while investigations are under way on the extent to which EMFs present a health hazard, we can limit our exposure.

- Do not spend more time than is necessary within a power-line right-of-way.
- Use electric blankets and mattress pads to preheat the bed only and unplug them when they are not in use.
- Old microwave ovens may leak a very small amount of electromagnetic radiation, so door seals and interlocks should be inspected and repaired if necessary.

Noise

In general, any noise exposure that can cause discomfort, dullness of hearing or ringing in the ear should be avoided.

- Reduce the volume on personal headset devices to safe levels. If a parent finds noise from toys uncomfortably loud when the toys are held near the ear, these toys should not be allowed to emit noise close to the child's ear.
- Use ear muffs or plugs when you are exposed to specific or prolonged noise levels, such as target shooting or operating machinery.
- Consult CMHC's land-use guidelines on environmental noise if you are planning to move to a neighbourhood where you are concerned about noise levels.
- Refer to your municipal bylaws and register complaints if the noise levels in your neighbourhood are offensive.
- If you are building a new home or renovating one, using double-glazed windows will reduce many unwanted outdoor sounds.

Appendix II
Sources of Additional Information

Federal Government Sources for Information on Health and the Environment

Topics	*Contact*
Health and Welfare Canada	Ottawa, Ontario K1A 0K9 Telephone (613) 957-2991
Chemicals, pesticides, micro-organisms, biotechnology, consumer products, indoor and outdoor air, hazardous waste, contaminated sites, Great Lakes, Canadian Environmental Protection Act, tobacco, drinking water, radiation, sound, nuclear emergencies, environmental impact assessments, toxicology, International Register of Potentially Toxic Chemicals	Environmental Health Directorate, Health Protection Branch
Food contaminants, chemicals and residues on food, Food and Drugs Act, foodborne illnesses, nutrition	Food Directorate, Health Protection Branch
Study of disease patterns, biosafety, epidemiology, cancer, birth defects, poisonings, environmental sensitivity, viruses, bacteria, biomedical waste	Laboratory Centre for Disease Control, Health Protection Branch
Food inspection, bottled water, regional offices and information	Field Operations Directorate, Health Protection Branch
Emergency Services	Health Advisory Services Directorate, Medical Services Branch
Native environmental health, public service health, Methylmercury Program, Arctic contaminants	Public Service Health Directorate, Medical Services Branch
Healthy Communities	Health Services and Promotion Branch
Physical fitness and lifestyle activities	Fitness and Amateur Sport

Topics	*Contact*
Agriculture Canada	Ottawa, Ontario K1A 0C5 Telephone (613) 995-5222
Pesticide registration, food production, farming practices	Food Production and Inspection Branch
Energy, Mines and Resources Canada	Ottawa, Ontario K1A 0E4 Telephone (613) 995-0947
Minerals	Geological Survey of Canada
Energy efficiency, fuels	Mineral and Energy Technology Sector
Environment Canada	Ottawa, Ontario K1A 0H3 Telephone (819) 997-2800
Air, climate change	Atmospheric Environment Service, 373 Sussex Drive, Block E
State of the Environment reporting	State of the Environment Reporting Office
Chemicals, water, waste management, Canadian Environmental Protection Act	Conservation and Protection
Environmental impact assessment	Federal Environmental Assessment Review Office, Fontaine Building, Hull, Quebec K1A OH3 Telephone (819) 997-1000
Indian and Northern Affairs Canada	Ottawa, Ontario K1A 0H4 Telephone (819) 997-0380 (publications)
Arctic, Native communities	
Fisheries and Oceans	Ottawa, Ontario K1A OE6 Telephone (613) 993-0600
Aquatic resources, fish	

Topics	*Contact*
Labour Canada	Hull, Quebec K1A 0J2 Telephone (819) 997-2617
Worker safety and health for federal employees	Occupational Safety and Health
Public Works Canada	Ottawa, Ontario K1A 0M2 Telephone (613) 736-2400
Indoor air quality in federal buildings	
Statistics Canada	Ottawa, Ontario K1A 0T6 Telephone (613) 951-8116
Health statistics, deaths, illness, disease trends, hospital admissions	Canadian Centre for Health Information
Transport Canada	Ottawa, Ontario K1A 0N5 Telephone (613) 990-2309
Transportation of dangerous goods	Transport of Dangerous Goods, Surface Group
Canada Mortgage and Housing Corporation	682 Montreal Road, Ottawa, Ontario K1A 0P7 Telephone (613) 748-2000
Buildings and indoor air quality problems, wood-burning stoves, energy efficiency	

Glossary

acceptable daily intake: The daily intake of a substance from all sources during a person's entire lifetime. This intake appears to be without appreciable risk on the basis of all known facts. It is usually expressed in milligrams of chemical per kilogram of body weight per day (mg/kg/d) and is also used to develop maximum acceptable concentrations.

acetycholine: A chemical that promotes the transmission of information between nerves. Some pesticides, such as organophosphates, make the enzyme responsible for breaking down acetylcholine inactive. This can result in serious toxic effects.

acute exposure: Short-term exposure to a substance.

adipose tissue: Fat tissue.

aflatoxin: A naturally occurring toxic substance formed by moulds of the genus *Aspergillus*. It can cause liver damage and cancer.

allergen: A substance that can cause an allergic reaction in a person who is sensitive to that substance.

Alzheimer's disease: A degenerative disease that affects the brain, usually in elderly people. Symptoms include profound confusion, memory loss and, often, personality changes.

ambient air: The air outdoors, as opposed to the air indoors.

antagonism: A state in which the presence of two or more substances acting together diminishes or decreases the toxic effects the substances would have if they acted independently. It is the opposite of synergism.

asbestosis: A disease in which lung tissue becomes scarred when a person inhales asbestos fibres.

asphyxiants: Gases and vapours that dilute the oxygen concentration in the lungs and may cause loss of consciousness or death. Nitrogen and carbon dioxide are two examples.

asthma: A disease in which the flow of air to and from a person's lungs is periodically obstructed when the air passages become narrow or plugged with excessive mucus. Symptoms include shortness of breath, coughing and wheezing.

atmosphere: The whole mass of air surrounding the earth. It extends to over 600 kilometres from the surface of the earth.

background levels: The levels of a particular substance that would normally exist if it were not affected by contaminants arising from a specific source. These are also sometimes referred to as "natural" levels of contamination and used as a reference point to measure additional levels of pollution.

becquerel: A measure of the intensity of radioactive material that has replaced curie as a standard unit. It represents one disintegration per second of the substance.

bioaccumulation: The process in which chemicals become more concentrated the higher they are located in the food chain. For example, seals contain more fat-soluble chemicals in their fat than the fish they eat, just as humans may contain more chemicals in their fat than the seal meat they eat.

bioavailability: The ability of a substance to be absorbed into the body.

biomedical waste: Waste from clinics, hospitals, nursing homes, and research laboratories. It may include any or all of the following: dressings and swabs, human and animal tissue, drugs, and medicinal implements such as needles.

biotechnology: The use of living organisms or parts of living organisms to manufacture goods that are useful to humans.

bronchitis: An inflammation of the mucous membranes of the bronchial tubes leading into the lungs. It causes a person to have difficulty breathing.

Brundtland Report: The 1987 Report of the World Commission on Environment and Development, called the "Brundtland Report" after its chairperson, Gro Harlem Brundtland. The report advocates the concept of sustainable development, in which economic expansion is balanced by respect for the environment and its people.

***Campylobacter*:** A type of bacteria made up of approximately 10 species. These bacteria may be found in untreated water and domestic animals, and can cause diarrhea.

cancer: An uncontrolled growth of cells that can invade and destroy body organs, causing incapacity or death.

carbamates: A group of organic compounds used as herbicides, fungicides or insecticides. They have a low to high toxicity to mammals and persist in the soil for only a short time. Carbamates used in Canada include aldicarb, carbaryl, and propoxur.

carcinogen: A cancer-causing agent.

chloracne: An acne-like skin disease arising from prolonged exposure to certain chlorinated compounds such as PCBs.

chlordane: A liquid insecticide consisting of highly chlorinated compounds.

chlorinated hydrocarbons: Chemicals containing chlorine, hydrogen and carbon. Examples are pesticides such as DDT, aldrin, and dieldrin.

chlorination: The process of adding chlorine to water to purify it for drinking.

chlorofluorocarbons (CFCs): A class of chemical compounds containing carbon, fluorine and chlorine. CFCs are manufactured chemicals commonly used as solvents, aerosol propellants, and refrigerants, and are implicated in destroying the ozone layer.

cholera: A bacterial infection spread by contaminated drinking water and infected food. *Vibrio cholerae* is the organism responsible for cholera.

chronic exposure: Long-term exposure to a substance.

chronic obstructive lung disease: A persistent disease in which the respiratory system is irreversibly damaged, leaving affected persons less able to breathe properly and fight off infection.

cirrhosis: A disease of the liver that develops over a long period of time.

coliforms: A group of bacteria normally found in the intestines of animals and humans. Their presence may be associated with fecal pollution. For example, scientists count fecal coliforms that are found in water at public beaches to determine whether swimming should be permitted.

communicable diseases: Diseases that can be transmitted from person to person.

confounding variables: Factors that make it difficult for researchers to pinpoint the specific cause of a particular effect on health. These variables include the presence of other chemicals in the environment, and the way in which chemicals react together. They also include people's differing physical conditions, lifestyles, and socio-economic factors.

contaminant: Any foreign substance, whether chemical or microbiological, that enters food, water, air, or soil. Naturally occurring substances such as aflatoxins are also considered contaminants.

cost-benefit analysis: An analysis of the cost of a certain course of action compared to its benefits.

dichlorodiphenyltrichloroethane (DDT): An insecticide that has been banned from use in many countries including Canada because of its persistence in the environment, and its toxicity to animals.

deoxyribonucleic acid (DNA): An essential compound found in the nucleus of living cells. DNA is a long-chain molecule that contains the genetic codes necessary for humans to develop and function.

dermatitis: An inflammation of the skin.

dose: The amount or concentration of a substance taken into the body.

dosimeter: A small, wearable device used to measure the concentrations of a pollutant over a period of time.

effluent: Any liquid that flows out of a containing space, particularly sewage or industrial waste that is partially or completely treated when it flows out of a treatment plant. For example, sewage effluent is the liquid finally discharged from a sewage treatment works.

electromagnetic fields: A combination of electric and magnetic fields that emanates from electric cables, wires, fixtures, and household appliances.

emphysema: A disease in which air accumulates in the lungs, stretching the tissue and leading to a loss of elasticity. Symptoms include laboured breathing, coughing and heart trouble.

enterococci: A type of bacteria in the intestinal tract of humans and animals that acts as an indicator of fecal pollution.

environmental sensitivity: A condition in which an individual is particularly sensitive to chemicals or other substances in his or her environment. Symptoms and causes vary widely from person to person. Reactions often include skin rashes, coughing and sneezing, fatigue, and depression.

enzymes: A group of organic catalysts formed in the cells of biological systems. Each enzyme initiates a certain chemical reaction such as the synthesis of proteins, or the conversion of starches to sugars.

epidemiology: The study of the occurrence and causes of disease in humans.

Escherichia coli (E. coli): A bacterium of the coliform group that lives in the intestines of humans and animals (several species are pathogenic).

exposure: The contact between a substance and a person or group of people. Exposure may occur by different means, including eating and drinking, breathing, and skin contact.

field trials: The use of a product such as a pesticide outside of contained facilities in order to test its effectiveness.

food chain: A sequence of organisms or food in which each is the food of the next member in the chain.

formaldehyde: A colourless gas with a pungent odour. It has been used in urea-formaldehyde insulation and is still used in furniture. It may cause health problems and discomfort when present in high concentrations in indoor air.

gene: The unit of heredity. A gene is made up of a specific segment of genetic material (DNA) that is carried from one generation to the next.

genetic engineering: A change in the genetic constitution of a living organism that has been brought about by artificial means and that usually would not occur in nature. An example would be the insertion of a gene from one species into another.

genetically engineered microorganisms: Microbes that have been artificially altered in such a way that they contain new or modified genes that allow the organism to exhibit new charcateristics.

genotoxin: A substance that can cause genetic damage.

giardiasis: An intestinal disease caused by the parasite *Giardia lamblia,* which may be present in untreated water used for drinking or washing food. This parasite can survive normal chlorination and can only be removed from the water supply by filtration.

greenhouse effect: The name given to the way in which gases such as chlorofluorocarbons, carbon dioxide, methane and nitrous oxide heat the earth. Concentrations of these gases are being increased by human activities, with the result that more energy is being trapped close to the earth. This condition, called global warming, could lead to warmer temperatures throughout the world.

halogenated compounds: A large group of chemicals containing chlorine, fluorine, iodine, or bromine. The group includes pesticides and byproducts from combustion processes.

halons: A group of manufactured chemical compounds containing carbon, bromine, fluorine and usually chlorine, and used primarily in fire extinguishers.

hazardous wastes: Wastes deemed hazardous to human health because of their toxicity, corrosiveness, flammability, explosiveness, and environmental persistence.

heavy metal: A dense metal of high relative atomic mass, for example, lead.

herbicide: A chemical used to kill weeds, shrubs, small trees, grasses, etc.

household hazardous waste (HHW): Wastes, found in and about the home, that can be dangerous to health. These include leftover cleaning products, pesticides, pool chemicals and pharmaceuticals.

hydrocarbon: An organic compound containing only the elements carbon and hydrogen. Hydrocarbons may be gases, liquids, or solids. Their chief sources are coal, natural gas, petroleum, and plant life. They are used as heating fuels, solvents, gasoline, and as starting materials for synthetic chemicals.

immune system: Collectively, the various cells and tissues that enable our bodies to fight off infection from invading micro-organisms, parasites, etc., thus protecting the body from infection.

immune system response: A response of the system of the body that normally protects against disease from invading organisms. The response is usually a mobilization of cells and production of certain biochemicals that defend the body.

immunocompromised: A term that describes an individual whose immune system is deficient, and is therefore more susceptible to infection.

incineration: A waste-reduction process in which material is burned under suitable conditions to reduce its volume or mass or both before disposal.

indicator: A measure of the extent to which a specific objective has been achieved. An indicator of the state of health and environment for a particular area might be the levels of chemical contaminants in the fat tissue of people living there. Researchers can use indicators over time to observe trends.

inorganic: Mineral in origin, not organic. Examples of inorganic substances are mercury, lead and asbestos.

insecticide: A chemical or biological substance that is especially toxic to insects either by ingestion or by body contact; it is applied to vegetation, crops, and insect-breeding areas.

ionizing radiation: Radiation with sufficient energy to knock electrons loose from molecules, forming "ions," atoms or groups of atoms having a positive or negative electric charge. These ions may then be able to act in ways they could not previously do. For example, they may damage body tissue; this in turn may damage the DNA and other body parts.

landfill: The disposal of waste by dumping it on land. Often refuse is used to fill in old mining sites or low-lying land. In some cases, waste is deposited in prepared sites.

legionnaires' disease: An illness similar to pneumonia and associated with a type of bacteria called *Legionella pneumophila*.

lymphoma: A cancer of lymphoid tissues. The lymphoid tissues produce the white blood cells that help to fight off infections.

maximum acceptable concentrations: The concentration of a substance that, if consumed daily for a lifetime, does not cause appreciable harm in the general population.

melanoma: A skin cancer that can appear as a new mole or pigmented spot on the skin, or as change in a mole or previously stable pigmented spot. Changes will be in the colour, size, surface or shape of the spot.

mesothelioma: Cancer of the lining of the lung or abdomen.

metabolism: The chemical changes in living organisms and cells by which nutrients used to provide energy and building materials for the cell or organism.

micro-organisms (microbes): Organisms too small to be seen with the naked eye, such as various types of bacteria, viruses, moulds, and algae.

monitoring: The repetitive and continued observation, measurement, and evaluation of health or the environment to examine changes over a period of time.

mutagen: A substance – for example radiation – that changes genetic material. When cell division occurs, these changes are transferred to the new cells, which then have changed characteristics.

mycotoxin: A toxic substance produced by some types of mould.

neurotoxins: Toxic substances that affect the nervous system of the body. Examples are lead, and methylmercury.

No-Observed-Adverse-Effect Level (NOAEL): A level of exposure to a chemical at which no adverse effects were observed during studies with animals.

non-Hodgkin's lymphoma: A type of cancer that affects the lymphatic system.

non-ionizing radiation: A form of radiation with less energy than ionizing radiation. It does not have sufficient energy to dislodge electrons, and so cannot damage human cells in the same way. However, since it can heat human tissue, some types of non-ionizing radiation may be harmful. Examples include ultraviolet radiation from the sun, radiation from microwave ovens, and infrared radiation from heat lamps.

non-melanoma skin cancer: A form of skin cancer that can be easily removed and is non-fatal, unlike melanoma.

organic: Chemicals containing carbon combined with hydrogen and often other elements such as oxygen or nitrogen. Examples are vegetable matter, petroleum, and plastics.

organochlorines: Organic chemicals containing chlorine. Some synthetic chemicals in this group are PCBs, DDT, and polyvinyl chloride.

organophosphates: Organic chemicals containing one or more phosphate groups (PO_4), often used as pesticides. Organophosphate pesticides are more toxic to insects than organochlorines, and break down more easily in the environment.

ozone: A gas made up of three atoms of oxygen. It occurs naturally in the upper atmosphere or ozone layer, where it is formed by the action of solar ultraviolet radiation. Ozone is also found at ground level, created by the presence of volatile organic compounds.

Paralytic Shellfish Poisoning (PSP): An illness that results when a person consumes shellfish such as oysters and mussels that have become poisonous by feeding on the microscopic alga *Alexandrium*. Numbness and tingling sensations in the tongue and mouth result, and high concentrations in the body may lead to complete respiratory failure in higher concentrations.

parasite: An organism that derives its food from a living organism of another species (the host) and usually lives in or on the body or cells of the host.

particulates: Fine solids suspended in the air. Examples are smoke particles and dust.

pathogen: A living organism (usually a micro-organism) that causes disease.

point-of-use device: A device used to treat water at its point of use, for example in the home, rather than at the water source.

polychlorinated biphenyls (PCBs): A group of 209 chemical compounds made up of carbon, hydrogen and chlorine. The use of PCBs has now been banned, but these chemicals were widely used as insulators and flame retardants because of their stability and low flammability.

polychlorinated dibenzodioxins (dioxins): A group of 75 organic compounds made up of carbon, hydrogen, chlorine and oxygen.

polychlorinated dibenzofurans (furans): A group of 135 organic compounds made up of carbon, hydrogen, chlorine, and oxygen. They generally result from industrial activity. Furans are closely linked to dioxins in their chemical structure, and the two are often discussed together.

polycyclic aromatic hydrocarbons (PAHs): A large group of chemical compounds containing benzene molecules. They occur in fossil fuels, particularly coal tars. They may be found in smoke, polluted river and marine sediments, or polluted soils.

Priority Substances List: A list of chemical substances compiled under the Canadian Environmental Protection Act. Once a chemical is placed on this list, its toxicity is assessed within three years. This assessment could lead to regulating the substance.

promotion: A state in which the combined effect of two substances is greater than the sum of their individual effects. It differs from synergism in that although one of the chemicals may have no obvious toxic effect, when it is in the presence of another substance it increases that substance's toxicity.

protozoa: One-celled animals, mostly free-living in water. Some species are pathogenic, causing diseases such as malaria and dysentery (from *Amoeba*). Protozoa are much larger than bacteria.

radiation: The emission or transfer of energy in the form of electromagnetic waves or particles.

radioisotopes: Elements that are radioactive. Some occur naturally, such as those in uranium, while others are produced by industries such as those involving nuclear power or nuclear weapons.

radium: A strongly radioactive element occurring in extremely small percentages in uranium ores found in Zaire, northern Canada, the United States and the former Soviet Union. Radium is a highly radioactive substance and must be kept in heavy lead containers to block off its ionizing radiation.

radon: An invisible, naturally occurring, inert radioactive gas that is a breakdown product of radium.

radon "daughters" or "progeny": The products of the decay of radon. Each of the "progeny" is an invisible radioactive particle that decays into another radioactive particle until finally a stable nonradioactive lead molecule is formed and no further radioactivity is produced. The progeny can attach to dust particles and, if inhaled, may cause lung cancer.

remediation: The process of returning a contaminated site to its original state, or as close to it as possible.

risk assessment: The process of identifying a risk and estimating its potential effects. The initial step in the risk determination process, it is followed by the development of options to deal with the risk.

risk/benefit analysis: A comparison of health or other benefits.

risk management: Selecting and implementing a strategy to control a risk. Afterwards, that strategy is monitored and evaluated.

stratosphere: The part of the earth's atmosphere from about 11 kilometres from the surface of the earth to about 29 kilometres.

sustainable development: A term used to describe a vision of development in which economic expansion is balanced by respect for the environment. The 1987 Report of the World Commission on Environment and Development defined sustainable development as "development which ensures that the use of resources and environment today does not damage prospects for their use by future generations."

synergism: A state in which the combined effect of two or more substances is greater than the sum of their separate effects. It is the opposite of antagonism.

temperature inversion: Under normal conditions, the temperature of the air decreases with increased altitude so that cool, heavy air sits on top of warmer, lighter air. However, during a temperature inversion, this situation is reversed, and the warm air lies over the cool. The cooler air cannot rise because it is heavier, so any air pollutants in it are trapped at ground level.

teratogen: An agent that causes birth defects.

threshold dose: The lowest dose of a substance at which a specific measurable effect is observed and below which no effect is observed.

threshold limit value: A concentration in air of a gas (and some other substances) to which most workers can be exposed daily without harm.

total suspended particulates (TSPs): Solid and liquid particles in the air that are too small to settle on the earth's surface under the influence of gravity.

toxaphene: A chlorine-containing insecticide that is part of the organochlorine group.

toxicology: The study of the adverse health effects of chemicals on living organisms.

trihalomethanes: A group of organic compounds formed when water containing organic matter is chlorinated.

tritium: the radioisotope of hydrogen.

troposphere: The part of the earth's atmosphere from the ground to about 11 kilometres from the surface of the earth.

viruses: Minute parasites visible only under the electron microscope. A wide variety of diseases, from the common cold to some forms of cancer, result from virus infections. Although they can remain dormant for long periods of time, viruses cannot grow outside of their human hosts; thus, their spread depends on person-to-person contact or contamination of water or air.

volatile organic compounds (VOCs): Organic gases and vapours in the air. Sources include the burning of fuels as well as solvents, coatings, and dry cleaning operations.

zero-risk principle: A principle stating that no level of risk is acceptable.

Some Units and Symbols

mL	millilitre, one thousandth of a litre
g	gram, the basic unit of weight or mass
mg	milligram, one thousandth of a gram
μg	microgram, one millionth of a gram
ng	nanogram, one billionth of a gram
kg	kilogram, one thousand grams
mg/kg	milligrams per kilogram, equal to parts per million (ppm)
μg/kg	micrograms per kilogram, equal to parts per billion (ppb)
ng/kg	nanograms per kilogram, equal to parts per trillion (ppt)
pg	picogram, equal to one millionth of a microgram
Bq	bequerel, one disintegration per second of a radioactive substance
Hz	hertz, frequency in cycles per second
Sv	sievert, unit of radiation dose equal to one joule of energy per kilogram of absorbing tissue. (The sievert replaces the REM as the internationally recognized unit of radiation dosage; 1 Sv = 100 REM.)

Did You Know?

One part per million is the same as:

- One minute in two years
- One inch in 16 miles/One millimetre in one kilometre
- One bad apple in 2 000 barrels
- One ounce in 32 tons/One gram in one thousand kilograms

One part per billion is the same as:

- One second in 32 years
- One inch in 16 000 miles/One millimetre in one thousand kilometres
- One drop in 10 000 gallons/one millilitre in one million litres
- One bad apple in two million barrels

One part per trillion is the same as:

- One second in 320 centuries
- One inch in 16 million miles/one millimetre in one million kilometres
- One grain of sugar in an Olympic-sized pool
- One bad apple in two billion barrels

Can You Sense It?

- Table salt becomes unpalatable at one part per thousand.
- Swimmers can detect chlorine at one part per million in the pool.
- Sensitive noses can detect the odour of fuel oil at one part per billion.
- We can't detect any chemical at one part per trillion without sensitive analytical equipment.

References

Reference numbers in the text are not necessarily in sequence and may occur more than once, since each refers to a publication number in the accompanying list.

1. O. Adams, "Life expectancy in Canada – An – overview," *Health Reports* 2, 4 (Canadian Centre for Health Information, Statistics Canada, 1990): 361–376.
2. Environment Canada, *Public Opinion and the Environment* (Ottawa, 1988).
3. Synergistics Consulting Ltd. and Environics Research Group, "Fall Tabular Results," *Environmental Monitor* (Dec. 5, 1990).
4. L.D. Pengelly, "Inhaled Doses of Contaminants from Ambient Air Pollution, Environmental Tobacco Smoke, and Self-Smoking," *Chronic Diseases in Canada*, 10, 2 (March 1989): 28–29.
5. Federal-Provincial Advisory Committee on Environmental and Occupational Health, *Exposure Guidelines for Residential Indoor Air Quality* (Ottawa, 1987).
6. M. Raizenne, R. Burnett, B. Stern, C. Franklin, and J.D. Spengler, "Acute Lung Function Responses to Ambient Acid Aerosol Exposures in Children," *Environmental Health Perspectives*, 79 (1989): 179–85.
7. P.E. Bijur and H.A. Ruff, "The Effects of Low to Moderate Lead Levels on Neurobehavioural Functioning in Children: Toward a Conceptual Model," *Journal of Developmental and Behavioral Pediatrics*, 10, 2 (April 1989): 103–9.
8. D.V. Bates and R. Sizto, "Relationship Between Air Pollutant Levels and Hospital Admissions in Southern Ontario," *Canadian Journal of Public Health*, 74 (March/April 1983): 117–22.
9. World Health Organization, *Our Planet, Our Health* (Geneva, 1989).
10. H.B.S. Conacher, R.A. Graham, W.H. Newsome, G.F. Graham, and P. Verdier, "The Health Protection Branch Total Diet Program: An Overview," *Canadian Institute of Food Science and Technology Journal*, 22, 4 (1989): 322–26.
11. Health and Welfare Canada, H.B.S. Conacher (Unpublished data, 1985–1988).
12. Statistics Canada, *Human Activity and the Environment* (Ottawa, 1986).
13. Health and Welfare Canada, "Bacteria in Raw Food," *Issues* (Health Protection Branch, Ottawa, February 8, 1989).
14. Environment Canada, *Water Fact Sheet 2* (Ottawa, 1988).
15. P.H. Hynes, *EarthRight* (Rocklin, California: Prima Publishing, 1990).
16. Health and Welfare Canada, "Drinking Water Guidelines," *Issues* (Health Protection Branch, Ottawa, September 20, 1990).
17. J.C. Méranger, K.S. Subramanian and C. Chalifoux, "Survey for Cadmium, Copper, Nickel, Lead, Zinc, Calcium and Magnesium in Canadian Drinking Water Supplies," *Journal of the Association of Official Analytical Chemists*, 64, 1 (1981).
18. P.R.W. Kendall, *Summary Report: The Quality of Drinking Water in Toronto: A Review of Tap Water, Bottled Water and Water Treated by a Point-of-Use Device* (City of Toronto, Department of Public Health, 1990).
19. Health and Welfare Canada, Field Operations Directorate, "Bottled Water in Canada" (unpublished data, November, 1991).
20. R.S. Tobin and W.J. Robertson, "Removal of Chemicals in Drinking Water by Point-of-Use Treatment Devices and Associated Microbiological Problems," *Environmental Health Review*, 31, 3 (Fall 1987): 66–70.
21. R.S. Tobin and W.M. Ward, "Guidelines for Canadian Recreational Water Quality," *Canadian Journal of Public Health*, 75, 1 (January/February 1984): 15–18.
22. P. Payment, "Viruses and Bathing Beach Quality," *Canadian Journal Public Health*, 75, 1 (January/February 1984): 43–49.

23. A.B. Morrison, "Recreational Water Quality and Human Health," *Canadian Journal of Public Health*, 75, 1 (January/February 1984): 13–14.
24. Health and Welfare Canada, *Guidelines for Canadian Recreational Water Quality* (Ottawa, in press).
25. J. Hilborn and M. Still, *Canadian Perspectives on Air Pollution* (Ottawa: Environment Canada, 1990).
26. D.S. Blumenthal, ed., *Introduction to Environmental Health* (New York: Springer Publishing Company, 1985).
27. M.R. Greenberg, ed., *Public Health and the Environment* (New York: Guildford Press, 1987).
28. N. Trieff, ed., *Environment and Health* (Ann Arbor: Ann Arbor Science Publications, 1980).
29. Labour Canada, *WHMIS in Your Workplace* (Ottawa, 1988).
30. W.B. Hendee, *Health Effects of Low-level Radiation* (Norwalk, Conn.: Appleton-Century-Crofts, 1984).
31. B. Wolfe and L.R. Wallis, "Health and Low-level Radiation: Turning Good News into Bad News," *Health Physics*, 55, 2 (August 1988): 361–66.
32. H.I. Morrison, R.M. Semenciw, Y. Mao and D.T. Wigle, "Cancer Mortality Among a Group of Fluorspar Miners Exposed to Radon Progeny," *American Journal of Epidemiology*, 128, 6 (1988): 1266–75.
33. P. Antonis, G. Berry, and M.L. Newhouse, "Combined Effect of Asbestos and Smoking on Mortality from Lung Cancer and Mesothelioma in Factory Workers," *British Journal of Industrial Medicine*, 42, 1 (January 1985): 12–18.
34. R.S. Kronenberg, "Asbestos Inhalation and Cigarette Smoke Make a Lethal Combination," *Occupational Health and Safety*, 58, 3 (March 1989): 50–68.
35. R. Begin, R. Boileau, and S. Peloquin, "Asbestos Exposure, Cigarette Smoking and Airflow Limitation in Long-term Canadian Chrysotile Miners," *American Journal of Industrial Medicine*, 11, 1 (1987): 55–66.
36. M.M. Finkelstein, "Mortality Among Employees of an Ontario Asbestos Cement Factory," *American Review of Respiratory Diseases*, 129, 5 (May 1984): 754–61.
37. Medical Research Council of Canada, "McGill University Team Researching Asbestos-related Lung Disease" (Information sheet, Ottawa, 1989).
38. M.E. McDowall, *The Identification of Man-made Environmental Hazards to Health* (London: Macmillan, 1987).
39. J.F. Crawford, M.H. Jackson, G.P. Morris, P.G. Smith, *Environmental Health Reference Book* (London: Butterworths, 1989).
40. C.E. Duncan, J. O'Heany, R. Kusiak, J.F. Smith, L.F. Smith, and L. Spielberg, "Blood Lead and Associated Risk Factors in Ontario Children," *Science of the Total Environment*, 71, 3 (June 1, 1988): 477–83.
41. L. Chenard, F. Turcotte, and S. Cordier, "Lead Absorption by Children Living Near a Primary Copper Smelter," *Canadian Journal of Public Health*, 78, 15 (September/October 1987): 295–98.
42. Health and Welfare Canada, *Poison Control Statistics* (Ottawa, 1987).
43. H.L. Needleman and G.A. Gatsonis, "Low-level Lead Exposure and the IQ of Children: a Meta-analysis of Modern Studies," *Journal of the American Medical Association*, 263, 5 (1990): 673–78.
44. Health and Welfare Canada, "Fluoride and Human Health," *Issues*, (Health Protection Branch, Ottawa, August 13, 1990).
45. D. Krewski, D. Wigle, D.B. Clayson and G.R. Howe, "Role of Epidemiology in Health Risk Assessment," *Recent Results in Cancer Research*, 120 (1990): 1–24.
46. A.B. Miller, "The Information Explosion – the role of the epidemiologist," *Cancer Forum*, 8 (1984): 67–75.
47. R. Doll and R. Peto, "The Causes of Cancer: quantitative estimates of avoidable risks of cancer in the United States today," *Journal of the National Cancer Institute*, 66 (1981): 1191–1308.
48. Health and Welfare Canada, *Proceedings of the Environmental Sensitivities Workshop* (Ottawa, 1990).
49. A. Lafontaine, "Public and Occupational Health Significance of Allergic Responses and Hypersensitivities Induced by Man-made Chemicals," *Proceedings of a Joint WHO/CEC Workshop on Allergic Responses and Hypersensitivities Induced by Chemicals* (Copenhagen, 1983).
50. B.G. Bennett, "Exposure Assessment for Metals involved in Carcinogenesis," *IARC Science Publication*, 71 (1986): 115–27.
51. S. Hirshorn, "Food Poisoning," *Canadian Consumer*, 9 (1989): 9–15.
52. Health and Welfare Canada, *Methylmercury in Canada: Exposure of Indian and Inuit Residents to Methylmercury in the Canadian Environment* (Ottawa, 1979).
53. G.B. Gerber, A. Leonard and P. Jacquet, "Toxicity, Mutagenicity and Teratogenicity of Lead," *Mutation Research*, 76 (1980): 115–41.
54. R.J. Perriman, "Controlling Toxic Chemicals in the Environment," *Journal of the Royal Society of Health*, 106, 1 (February 1986): 10–12.
55. World Health Organization and United Nations Environment Programme, and Global Pollution and Health, *GEMS: Global Environment Monitoring System* (Geneva, 1987).

56. Health and Welfare Canada, "Lead and Human Health," *Issues* (Health Protection Branch, Ottawa, February 10, 1989).
57. Health and Welfare Canada, *Guidelines for Canadian Drinking Water Quality* (4th Edition, Ottawa: Supply and Services Canada, 1989).
58. J. Sitwell and G. Wood, "The Canadian Drinking Water Guidelines for Lead," *Environmental Geochemistry and Health*, 12 (1990), Supplement: 51–62.
59. G. Pershagen, "Sources of Exposure and Biological Effects of Arsenic," *IARC Science Publication*, 71 (1986): 45–61.
60. R. Philipp, "Arsenic Exposure: Health Effects and the Risk of Cancer," *Reviews on Environmental Health*, 5, 1 (1985): 27–57.
61. Health and Welfare Canada, "Aluminum and Human Health," *Issues* (Health Protection Branch, Ottawa, March 6, 1989).
62. R.J. Hill, "Aluminum" (unpublished document prepared for Health and Welfare Canada, 1990).
63. D.P. Perl, "Relationship of Aluminum to Alzheimer's Disease," *Environmental Health Perspectives*, 63 (November 1985): 149–53.
64. S. Kirkey, "Aluminum and Alzheimer's," *The Citizen* [Ottawa], January 25, 1991, F1.
65. Editorial, "Acid Rain and Human Health," *The Lancet*, 1, 8429 (March 16, 1985): 616–18.
66. C.N. Martyn, "Geographical Relation Between Alzheimer's and Aluminum in Drinking Water," *The Lancet*, 1, 8629 (January 1989): 59–62.
67. L.C. Neri and D. Hewitt, "Aging and Water Constituents: A Pilot Study," (Health and Welfare Canada contract paper, 1991).
68. M.J. Abramson, J.H. Wlodarczyk, N.A. Saunders, and M.J. Hensley, "Does Aluminum Smelting Cause Lung Disease?" *American Review of Respiratory Diseases*, 139, 4 (April 1989): 1042–57.
69. R.J. Boegman and L.A. Bates, "Neurotoxicity of Aluminum," *Canadian Journal of Physiology and Pharmacology*, 62 (August 1984): 1010–14.
70. D.M. Bernstein, R.T. Drew, and M. Kuschner, "The solubility of man-made mineral fibers in the lung in contrast to natural fibers" (Basel, Switzerland: Research and Consulting Company AG, undated).
71. Health and Welfare Canada, "Asbestos," *Issues* (Health Protection Branch, Ottawa, September 11, 1989).
72. T. Furmanczyk, Department of the Environment (unpublished data, October, 1991).
73. B. Stern, L. Jones, M. Raizenne, R. Burnett, J.C. Méranger, and C.A. Franklin, "Respiratory Health Effects Associated with Ambient Sulfates and Ozone in Two Rural Canadian Communities," *Environmental Research*, 49 (1989): 20–39.
74. C.A. Franklin and R.T. Burnett, "Health Risks from Acid Rain: a Canadian Perspective," *Environmental Health Perspectives*, 63 (November 1985): 155–68.
75. M. Keating, *Towards a Common Future: a Report on Sustainable Development and its Implications for Canada* (Ottawa: Environment Canada, 1989).
76. D.V. Bates and R. Sizto, "The Ontario Air Pollution Study: Identification of the Causative Agent," *Environmental Health Perspectives*, 79 (February 1989): 69–72.
77. D.E. Griffith and J.L. Levin, "Respiratory Effects of Outdoor Air Pollution," *Postgraduate Medicine*, 86, 5 (October 1989): 111–16, 118.
78. A. Blair, "Herbicides and Non-Hodgkins Lymphoma: New Evidence From a Study of Saskatchewan Farmers," *Journal of the National Cancer Institute*, 82, 7 (April 4, 1990): 544–45.
79. D. Riedel, "A Review of the Toxicology of the Herbicide 2,4-D (2,4-Dichlorophenoxyacetic)," *Chronic Diseases in Canada*, 4, 1 (June 1983): 4–6.
80. D.T. Wigle, R.M. Semenciw, K. Wilkins, D. Riedel, L. Ritter, H.I. Morrison, and Y. Mao, "Mortality Study of Canadian Male Farm Operators: Non-Hodgkin's Lymphoma Mortality and Agricultural Practices in Saskatchewan," *Journal of the National Cancer Institute*, 82, 7 (April 4, 1990): 575–82.
81. Health and Welfare Canada, "Dene Exposure to Toxaphene: Summary of findings of the Toxaphene Steering Committee" (unpublished, Ottawa, 1989).
82. Alachlor Review Board, *The Report of the Alachlor Review Board* (Ottawa, 1987).
83. J. Mes, "Trends in the Levels of Some Chlorinated Hydrocarbon Residues in Adipose Tissue of Canadians," *Environmental Pollution*, 65 (1990): 269–78.
84. Government of Canada, *PCB Fact Sheets* (Ottawa, undated).
85. Health and Welfare Canada, "Multi-Media Exposure Analysis for Polychlorinated Biphenyls" (unpublished report prepared for the Federal-Provincial Multi-Media Guidelines Advisory Committee, Ottawa, May 1990).
86. D. Kinloch and H. V. Kuhnlein, *Assessment of PCBs in Arctic Foods And Diets: A Pilot study in Broughton Island, Northwest Territories* (Health and Welfare Canada pilot study, 1987).
87. D. Kinloch, H. Kuhnlein and D. Muir, *Inuit Foods and Diet: A Preliminary Assessment of Benefits and Risks* (Health and Welfare Canada study, 1990).

88. J.L Jacobson, S.W. Jacobson, and H.E.B. Humphrey, "Effects of Exposure to PCBs and Related Compounds on Growth and Activity in Children," *Neurotoxicology and Teratology*, 12 (1990): 319–26.
89. J.L. Jacobson, S.W. Jacobson, and H.E.B. Humphrey, "Effects on In Utero Exposure to Polychlorinated Biphenyls and Related Contaminants on Cognitive Functioning in Young Children," *The Journal of Pediatrics*, 116, 1 (January 1990): 38–45.
90. J. Mes, D.J. Davies, D. Turton, and W.-F. Sun, "Levels and trends of chlorinated hydrocarbon contaminants in the breast milk of Canadian women," *Food Additives and Contaminants*, 3, 4 (1986): 313–22.
91. Health and Welfare Canada, "Pulp and Paper Mill Effluents," *Issues* (Health Protection Branch, Ottawa, August 15, 1991).
92. Department of Fisheries and Oceans, "Closure of Fisheries Areas," (News Release, Ottawa, November 30, 1988).
93. Department of Fisheries and Oceans, "Shellfish Fishery Closures and Comsumption Advisories, B.C." (Backgrounder, Ottawa, November 29, 1990).
94. British Columbia, Ministry of Environment and Ministry of Health News Release (May 19, 1989).
95. Department of Fisheries and Oceans, "Dioxins and Furans" (Backgrounder, Ottawa, September, 1991).
96. A. Gilman and R. Newhook, "An Updated Assessment of the Exposure of Canadians to Dioxins and Furans" (unpublished, 1991).
97. Government of Alberta, *Clean Air Strategy for Alberta Information Kit* (Edmonton, 1990).
98. J.S. Hoffman, ed. "An Assessment of the Risks of Stratospheric Modification," (U.S. Environmental Protection Agency, March 1987).
99. Data provided by the Canadian Centre for Health Information, Statistics Canada, June 1991.
100. Canada Mortgage and Housing Corporation, *That Nice Woodsy Smell: Combustion Spillage from Residential Wood Heating Systems* (Ottawa: March 1991).
101. Health and Welfare Canada, Environmental Health Directorate, "Evaluation Report on the Sysco Coke Plant" (unpublished, May 1985).
102. Health and Welfare Canada, "Cancer Risk in Fishermen Related to Contamination of Sydney Harbour, Nova Scotia" (unpublished, 1991).
103. R.A. Denison and E.K. Silbergeld, "Risks of Municipal Solid Waste Incineration: an Environmental Perspective," *Risk Analysis*, 8, 3 (1988): 343–55.
104. E.C. Todd, *Foodborne Disease in Canada: A 10-Year Summary, 1975–1984* (Ottawa: Health and Welfare Canada, 1991).
105. E.C. Todd, *Foodborne and Waterborne Disease in Canada, Annual Summaries, 1985 and 1986* (Ottawa: Health and Welfare Canada, 1991).
106. J.M. Farber, "Foodborne Pathogenic Microorganisms: Characteristics of the Organisms and Their Associated Disease, I. Bacteria," *Canadian Institute of Food Science Technology*, 22, 4, (1989).
107. Health and Welfare Canada, "Barbecue Syndrome," *Issues* (Health Protection Branch, Ottawa, July 16) 1990.
108. Health and Welfare Canada, "Aflatoxins," *Issues* (Health Protection Branch, Ottawa, May 29, 1990).
109. Health and Welfare Canada, "Parasites, a Health Threat in Raw Food," *Issues* (Health Protection Branch, Ottawa, February 13, 1989).
110. C.E. Tanner, *Native Health in Northern Quebec in Relation to Resource Harvesting and Parasitic Zoonoses* (National Health Research and Development Program, 1986).
111. E.C. Todd, "Chronology of the Toxic Mussels Outbreak," *Canada Diseases Weekly Report Supplement: Proceedings of a Symposium on Domoic Acid*, 16S1E (Health and Welfare Canada, September 1990): 3–4.
112. E.C. Todd, "Foodborne and Waterborne Disease in Canada – 1983 Annual Summary," *Journal of Food Protection*, 52, 6 (June 1989): 436–42.
113. Canadian Healthy Communities Project, *Challenge/Change*, 1, 3 (September 1989).
114. Quebec Ministry of the Environment, *Operation Beach-Environment*, (Quebec, 1988).
115. D.J. Miller, "Fungi as Contaminants in Indoor Air," *Proceedings of the Fifth International Conference on Indoor Air Quality and Climate* (Ottawa, 1990).
116. Health and Welfare Canada Working Group on Fungi and Indoor Air, *Significance of Fungi in Indoor Air: Report of a Working Group* (Ottawa, 1987).
117. S. Prentis, *Biotechnology: A New Industrial Revolution* (New York: George Braziller Inc., 1984).
118. C. Nelles, "The Environmental and Health Impacts Associated with the Release of Genetically Engineered Organisms" (unpublished report prepared for Health and Welfare Canada).
119. Environment Canada, *Proposed notification regulations for Biotechnology products under the Canadian Environmental Protection Act* (Ottawa, 1990).
120. Government of Canada, *Bio-tech Regulations: A User's Guide* (Ottawa, 1988).

[redacted]

121. Medical Research Council of Canada/Health and Welfare Canada, *Laboratory Biosafety Guidelines* (Ottawa, 1990).

122. E.G. Letourneau, R.G. McGregor, and W. B. Walker, "Design and Interpretation of Large Surveys for Indoor Exposure to Radon Daughters," *Radiation Protection Dosimetry*, 7, 1–4 (1984): 303–8.

123. Health and Welfare Canada, Medical Services Branch, "Mercury, Fish and You; Mercury, Questions and Answers" (Ottawa, 1990).

124. J.P. Ashmore and D. Grogan, "Dose Statistics for Nuclear Fuel Cycle Workers in Canada" (Vienna: International Atomic Agency, 1980).

125. J.P. Ashmore and B.F. Davies, *The National Dose Registry: a Centralized Record Keeping System for Radiation Workers in Canada* (Ottawa: Health and Welfare Canada, 1987).

126. United Nations Scientific Committee on the Effects of Atomic Radiation, "Genetic and somatic effects of ionizing radiation" (1986 Report to the General Assembly, with Annexes, New York: United Nations, 1986).

127. "Annual Summary and Assessment of Environmental Radiological Data for 1989," HST-TS-90-4 (Prepared by SENES Consultants for Ontario Hydro, Toronto: April, 1990).

128. A.P. Watson, "Polonium-210 and Lead-210 in Food and Tobacco Products: Transfer Parameters and Normal Exposure and Dose," *Nuclear Safety*, 26 (1985): 179–191.

129. United Nations Scientific Committee on the Effects of Atomic Radiation, "Sources, effects and risks of ionizing radiation" (1986 Report to the General Assembly, with Annexes, New York: United Nations, 1988).

130. Energy Mines and Resources Canada, Environment Canada, and Health and Welfare Canada, "Environmental, Health and Safety Aspects of Coal-fuelled Electrical Power Generation in Canada" (unpublished paper, Ottawa, July 1980).

131. Health and Welfare Canada, *Environmental Radioactivity in Canada, 1988: Radiological Monitoring Annual Report* (and others in this series, Ottawa, 1991).

132. Health and Welfare Canada, *Environmental Radioactivity in Canada, July-December, 1978*, Environmental Health Directorate Report 79-EHD-38 (1978).

133. W.K. Gummer, R.R. Campbell, G.B. Knight and J.L. Ricard, *Cosmos 954 – The Occurrence and Nature of Recovered Debris* (Ottawa: Supply and Services Canada, INFO-006).

134. Health and Welfare Canada, *Environmental Radioactivity in Canada – 1979* (Ottawa, 1979).

135. J.G. Kemeny (Chairman), *Report of the President's Commission on the Accident at Three Mile Island* (New York: Pergamon Press, 1979).

136. Health and Welfare Canada, *Environmental Radioactivity in Canada – 1976*, Environmental Health Directorate Report 87-EHD-126 (1976).

137. W. Huda, "Chernobyl – the Radiological Impact on Canada," *Journal of the Canadian Association of Radiologists*, 39 (1988): 39–41.

138. Health and Welfare Canada, *Environmental Radioactivity in Canada – 1988*, Environmental Health Directorate Report EHD-TR-152 (Ottawa: Supply and Services Canada, 1991).

139. R.S. Eaton, "A case-control study of lung cancer and domestic exposure to radon: Study methodology and data collection status," *Proceedings of the Fifth International Conference on Indoor Air Quality and Climate* (Ottawa, 1990).

140. R.S. Eaton, "Radon: Is It Really Dangerous? Technical and Social Aspects," *Emergency Preparedness Digest*, 15, 2 (April-June 1988): 12–17.

141. L.B. Travis and Kenneth Arndt, "Occupational Skin Cancer," *Postgraduate Medicine*, 79, 6 (May 1, 1986): 211–14, 217.

142. G. Chaloner-Larsson, "Study on Environmental Health Hazards, Pathways and Effects" (Unpublished document prepared for Health and Welfare Canada, 1990).

143. M.G. Morgan, *Electric and Magnetic Fields from 60 Hz Electric Power: What do we know about possible health risks?* (Pittsburgh: Carnegie Mellon University, 1989).

144. R. Pool, "Is there an EMF-cancer connection?" *Science*, 249 (September 7, 1990): 1096–98.

145. M.G. Morgan, "Electric and Magnetic Fields from 60 Hz Electric Power: Possible Health Risks?" *Chance: New Directions for Statistics and Computing*, 2, 4 (1989): 12–20, 37.

146. R. Pool, "Electromagnetic Fields: the Biological Evidence," *Science*, 249 (September 21, 1990): 1378–83.

147. Health and Welfare Canada, *Noise Hazard and Control*, 79-EHD-29 (Ottawa, 1979).

148. OECD, *Fighting noise. Strengthening noise abatement policies* (Paris: Organization for Economic Cooperation and Development Publications, 1986).

149. B. Berglund, T. Lindvall and S. Nordin, "Adverse Effects of Aircraft Noise," *Environment International*, 16, 4-5-6 (1990): 313–14.

150. World Health Organization, *Environmental Health Criteria 12* (Geneva, 1980).

151. U.S. Department of Health and Human Services, *Noise and Hearing Loss* (Consensus Statement, NIH Consensus Development Conference, January 22–24, 1990), Vol. 8 (1).

152. J. Rosenberg, "Jets over Labrador and Quebec: noise effects on human health," *Canadian Medical Association Journal*, 144, 7 (1991): 869–75.

153. Canadian Public Health Association, *CPHA Task force on the Health Effects of Increased Flying Activity in the Labrador Area* (Ottawa, 1987).

154. Federal-Provincial Advisory Committee on Environmental and Occupational Health (Canada), A Working Group on Environmental Noise, *National Guidelines for Environmental Noise Control: Procedures and concepts for the drafting of environmental noise regulations/by-laws in Canada* (Health and Welfare Canada, Environmental Health Directorate, Ottawa, 1989).

155. G.M. Marsh and R.J. Caplan, "Evaluating Health Effects of Exposure at Hazardous Waste Sites: a Review of the State-of-the-Art, with Recommendations for Future Research," J.B. Andelman and D.W. Underhill (eds.), *Health Effects from Hazardous Waste Sites* (Chelsea, Michigan: Lewis Publishers, 1987).

156. J.B. Andelman and D.W. Underhill, *Health Effects from Hazardous Waste Sites* (Chelsea, Michigan: Lewis Publishers, 1987).

157. P.J. Hess, "Groundwater Use in Canada, 1981," *IWD Technical Bulletin*, 140 (Environment Canada, Natural Hydrology Research Institute paper No. 28).

158. Environment Canada, *National Inventory of Muncipal Waterworks and Waste Water Systems in Canada* (Ottawa, 1986).

159. J. Noble, "Biodegradation in Landfills," *Health & Environment Digest*, 3, 9 (November 1989): 1–3.

160. D. Orchard, "The Green Plan: A National Challenge for Canada," *Journal of Air and Waste Management Association*, 41, 3 (March 1991): 268–71.

161. Environment Canada, Waste Management Branch (Personal communication, 1991).

162. L. Fishbein, "Potential Metal Toxicity from Hazardous Waste Incineration," *Toxicological and Environmental Chemistry*, 18 (1989): 287–309.

163. J.R. Nethercott and D.L. Holness, "Health Status of a Group of Sewage Treatment Workers in Toronto, Canada," *American Industrial Hygiene Association Journal*, 49, 7 (1988): 346–50.

164. W. Rutala, R. Odette, and G. Samsa, "Management of Infectious Waste by U.S. Hospitals," *Journal of the American Medical Association*, 262, 12 (September 22/29 1989): 1635–40.

165. Council on Scientific Affairs, "Infectious Medical Wastes," *Journal of the American Medical Association*, 262, 12 (September 22/29): 1669–71.

166. Canadian Standards Association, *Handling of Waste Materials within the Health Care Facilities: A National Standard of Canada* (Toronto, 1988).

167. A. Leaf, "Potential Health Effects of Global, Climatic and Environmental Changes," *New England Journal of Medicine*, 312, 23 (1989): 1577–83.

168. United Nations Environment Programme, *Industry and Environment*, Industry and Environment Office, Vol. 13(2) 1990: 2–8.

169. Federal/Provincial Research Committee and Monitoring Coordinating Committee (RMCC), *The 1990 Canadian Long-Range Transport of Air Pollutants and Acid Deposition Assessment Report: Part Six, Human Health Effects* (Environmental Health Directorate, Health and Welfare Canada, 1990).

170. L.C. Hum and R. Semenciw, "Mortality Patterns in Canada, 1988," *Chronic Diseases in Canada* (March 1991): 16–19.

171. Health and Welfare Canada, *Health Risk Determination* (Ottawa, 1990).

172. The British Medical Association, *Living With Risk: The British Medical Association Guide* (Chichester: John Wiley and Sons, 1987), p. 23.

173. K.C. Johnson and J. Rouleau, *Tritium releases from Pickering Nuclear Generating Station and Birth Defects and Infant Mortality in Nearby Communities 1973–1988* (Health and Welfare Canada report prepared for the Atomic Energy Control Board, 1991).

174. National Cancer Institute of Canada, *Canadian Cancer Statistics 1991* (Toronto, 1991).

175. United Nations Environment Programme, *Environmental Data Report*, Third Edition, 1991/92 (UNEP, 1991), p. 240.

176. D. Krewski, T. Miller, R.S. Eaton, D.P. Meyerhof and E.G. Letourneau, "Managing Environmental Radon Risks: A Canadian Perspective," in *Management of Risk from Genotoxic Substances in the Environment*, ed. L. Freij (Stockholm: Swedish National Chemicals Inspectorate, 1989), 242–257.

177. T. Hancock, "Sustaining Health: Achieving Health for All in a Secure Environment" (Health, Environment, Economy Conference, Toronto, 1989).

178. World Health Organization, Health and Welfare Canada, and the Canadian Public Health Organization, *Ottawa Charter of Health Promotion* (Ottawa, 1986).

179. World Commission on Environment and Development, *Our Common-Future* (Oxford University Press, 1987).

180. Environment Canada, *From Backyards to Borders: Federal Environmental Action in Canada's Communities* (Ottawa, 1988).

181. *Noordwijk Declaration on Climate Change* (from the Ministerial Conference on Atmospheric Pollution and Climatic Change held at Noordwijk, Netherlands, November 1989).
182. International Joint Commission, *Fifth Biennial Report on Great Lakes Water Quality* (Ottawa, 1989).
183. Ecosystem Objectives Working Group, *Ecosystem Objectives for Lake Ontario*, 1990.
184. Government of Canada, *Canada's Green Plan*, 1990.
185. World Health Organization and United Nations Environmental Programme, *The Human Exposure Assessment Location Project* (Washington, undated).
186. Health and Welfare Canada, *International Register of Potentially Toxic Chemicals: IRPTC Databases On-line* (Ottawa, 1990).
187. T. Cochlin and R. Connelly, "Human Health Considerations in Federal Environmental Assessment Panel Reviews" (speech given at the National Conference on Environmental Health Issues, 1990).
188. Federal Environmental Assessment Review Office, *Federal Environmental Assessment: New Directions* (1990).
189. Canadian Environmental Protection Act, R.S.C. 1985, c. 16 (4th Supp.).
190. Health and Welfare Canada, "Great Lakes: Action on Human Health Concerns Now," *Issues* (Health Protection Branch, Ottawa, May 1990).
191. Government of Canada, *Toxic Chemicals in the Great Lakes and Associated Effects: Synopsis* (Ottawa, 1991).
192. Health and Welfare Canada, *Emergency Services: Information Pamphlet* (Ottawa, 1985).
193. Health and Welfare Canada, "Federal Nuclear Emergency Response Plan," *Issues* (draft, 1991).
194. B. Small, "Healthy environments for Canadians: making the vision a reality," *Health Promotion*, 27, 4 (Spring 1989): 2–7.
195. T. Hancock, *Toward Healthy and Sustainable Communities: Health, Environment and Economy at the Local Level* (3rd Colloquium on Environmental Health, Quebec, November 22, 1990).
196. Health and Welfare Canada, *Achieving Health for All: A Framework for Health Promotion* (Ottawa, 1986).
197. A.W. Myres and M.S. Wiedeman, "The Health Concerns of Canadians: A Perspective From the Green Plan Consultations on the Environment," *Environmental Health Review*, Fall (1991): 70–77.

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